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MEMOIRS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

PALÆONTOLOGY.

MONOGRAPH

ON

THE HIGHER CRUSTACEA

OF

THE CARBONIFEROUS ROCKS OF SCOTLAND.

BY

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INTRODUCTION.

In the year 1880,[1] while acting as Palæontologist to the Scottish branch of the Geological Survey, I described several species of the higher Crustacea from the Carboniferous Rocks of Scotland, in a memoir communicated to the Royal Society of Edinburgh, by the permission of Sir A. C. Ramsay, then Director-General of the Survey. Again, in 1882,[2] his successor, Sir Archibald Geikie, sanctioned a further contribution to that Society upon the additional remains of higher Crustacea that had been brought to light in the interval from the same rocks. From that time, up to the date of my retirement in 1905, fresh material steadily accumulated till the collection of the Scottish branch of the Survey became unrivalled in the amount and variety of the remains of the higher Crustacea from the Carboniferous Rocks. Although acting as Palæontologist and taking a special interest in these treasures, I was unable to give the necessary time to the description of the new materials owing to more pressing duties connected with field work; but I devoted occasional intervals to drawing and studying some of the specimens. My retirement has given me ample leisure for the work, and by the kindness of my old friend and colleague, Dr. Horne, the Assistant to the Director in Scotland, and of Dr. Teall, the present Director of the Geological Survey, I have had the great good fortune to be allowed to pursue this research.

From an examination of the specimens collected since 1882, many of which are in excellent preservation, it became evident that the classification of the forms already described, not only by myself but by other investigators, was defective and often erroneous, and that the materials for correcting these mistakes were to be found in the collection of the Geological Survey. Nearly all the remains of the higher Crustacea from the Carboniferous Rocks were formerly classed with the macrurous Decapods, but the preliminary study of the fossils as they accumulated led me to the belief that they have closer affinities with the Schizopods. The publication in 1885 of the report by G. O. Sars, on the Schizopoda obtained by the Challenger Expedition, was

[1] Trans. Roy. Soc. of Edin., vol. xxx, p. 73. (1882).
[2] *Ibid.*, p. 511. (1883).

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of special interest to me, as it proved that my conclusion was based upon sound evidence. Recent "finds" of almost perfectly preserved Lophogastrids from the Carboniferous Rocks exposed on the Gullane Shore, East Lothian, by Mr. Macconochie, have placed this correlation beyond all doubt.

Another advance of marked significance, in the interval referred to, was the discovery of a living representative of a family of fossil Crustacea which occurs in the Scottish Carboniferous Rocks. It was found in a fresh-water lake high up on Mount Wellington in Tasmania, and was fully described by W. T. Calman, B.Sc.,[1] before the Royal Society of Edinburgh in 1896, his description being published in the Transactions of that Society of the following year.

In dealing with the classification of fossil Crustacea, one is met at the very outset with difficulties, owing to the imperfectly preserved material available, that do not occur to the carcinologist who deals with living forms. One must therefore base the classification upon characters that are fairly shown upon the parts that fossilise most readily—a method which is far from satisfactory. It is therefore most gratifying to be able to work with such splendidly preserved material as is afforded by the remains of the Lophogastrid genus *Tealliocaris*, obtained by Mr. Macconochie from the Carboniferous Rocks of the Gullane Shore, and the nearly equally well preserved Euphausiid remains of *Anthracophausia* from the Cementstone Group of Duns, Berwickshire. In the former case, such delicate structures as gills and breeding lamellæ, and in the latter, such organs as the row of luminous globules on the trunk and tail and the coupling hooks on the male sexual organs, are well shown.

The classification here followed is chiefly based upon that adopted by G. O. Sars in his Report on the Schizopoda of the Challenger Expedition. The Schizopoda are arranged in two great groups, viz. :—(I.) The Mysid Group, including the families Lophogastridæ, Perimecturidæ, Anaspidæ, and Mysidæ. (II.) The Euphausiid Group has only one family, Euphausiidæ.

The Lophogastridæ are regarded as the culmination of the Mysid Group and as having reached their fullest development in late Palæozoic time, when they evidently took the place now occupied by the macrurous and anomurous Decapods. At that time they assumed several forms to suit environment, but they underwent no further development. The recent Lophogastrids are looked upon as having been preserved through having migrated to the deep sea, and, like survivors of ancient families, were evidently not the most specialised members.

The Perimecturidæ are considered to have branched off from the Mysid stem

[1] Trans. Roy. Soc. Edin., vol. xxxviii., page 787.

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together with the Lophogastridæ, and appear to have been still undergoing development in Carboniferous time. Indeed, it is highly probable that some member of the family gave rise to the Squillid stock during, or soon after, the Carboniferous period, after which they became extinct.

The Anaspidæ are also regarded as having branched off from the common Mysid stem along with the two former families, and to have retained more primitive characters than the others. They also seem to have reached their maximum development during late Palæozoic time. One branch of them, by retaining their larval eyes, probably gave rise to the modern Isopods and Amphipods by a very easy transmutation, and seem to have been ousted by their more advanced descendants, their sole known survivor having taken to a fresh-water habitat in Tasmania, a country that has long been isolated and rendered comparatively free from severe competition.

The Mysidæ appear to have been even more highly specialised in Carboniferous than in modern times. The structure of the existing members of the family seems to have been simplified chiefly through degeneration.

The Euphausiidæ seem to have been evolved from a Nebalid stock and to have reached their full development in Carboniferous time, taking the place then that is now occupied by our prawns and shrimps. The survivors have migrated to the open sea, where the struggle for existence is not so severe as along the shore. It is from the Euphausiid stock that the Decapods have evidently arisen, and the evidence supplied by the Scottish Carboniferous Rocks seems to favour the opinion that the branching off had not even begun in the Carboniferous period.

The following Table shows the genera and species grouped under the various families already enumerated. Of the 34 species of fossil Schizopods, no fewer than 29 are represented in the Collection of the Geological Survey, while, of the remaining five species, three are represented in the Natural History Collection of the Royal Scottish Museum, Edinburgh :—

[SCHEME.

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SCHEME OF CLASSIFICATION.

Sub-Order.	Group.	Family.	Genus.	Species and Variety.	Page.
Schizopoda	Group I. The Mysid Group	Lophogastridæ	Tealliocaris	loudonensis *sp. nov.*	9
				woodwardi (*R. Ether. jun.*)	18
				„ *var.*	22
				etheridgei (*Peach*)	22
				„ *var.* lata (*Peach*)	23
				robusta *sp. nov.*	24
				„ *var. nov.*	25
				tarrasiana *sp. nov.*	26
				formosa *Peach*	27
			Pseudo-Galathea	macconochiei (*R. Ether. jun.*)	28
				rotunda *Peach*	28
				ornatissima *Peach*	29
			Anthrapalæmon	russellianus (*Salter*)	30
				„ *var.* spinulosus *var. nov.*	36
			Pygocephalus	cooperi *Huxley*	37
		Perimecturidæ	Perimecturus	parki (*Peach*)	40
				„ *var* duplicicarinatus *var. nov.*	41
				stocki *sp. nov.*	42
				elegans *sp. nov.*	44
				communis *sp. nov.*	47
				ensifer *sp. nov.*	49
				pattoni *sp. nov.*	51
		Anaspidæ	Palæocaris	scotica *Peach*	54
				landsboroughi *sp. nov.*	55
		Mysidæ	Palæmysis	dunlopi *sp. nov.*	57
				couttsi *sp. nov.*	59
				tenuis *sp. nov.*	60
				sp.	60
	Group II. The Euphausiid Group	Euphausiidæ	Anthracophausia	dunsiana *sp. nov.*	61
				„ *var.* obesa *var. nov.*	66
				traquairi (*Peach*)	67
			Crangopsis	socialis *Salter*	69
				rhodesi *sp. nov.*	73
				magna *sp. nov.*	75
				couttsi *sp. nov.*	76
				robusta *sp. nov.*	78
				minuta *sp. nov.*	80
				eskdalensis (*Peach*)	80
				elegans (*Peach*)	81
				hastata *sp. nov.*	82
				huxleyi (*H. Woodw.*)	82

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As the terminology relating to this branch of research has undergone considerable modification since the publication of my previous papers in the Transactions of the Royal Society of Edinburgh, the following table has been prepared to show the equivalent technical terms, those used in the earlier papers being placed in brackets after the terms adopted in the present memoir.

Great Divisions of Body.

Trunk, including Head (Cephalo-thorax).

Tail, including Telson (Abdomen).

Larger Structures of Trunk.

Carapace.—Rostrum; cervical fold; gastric region; side wings and lappets; orbital, antennal, and branchiostegal spines.

Trunk Segments (Thoracic segments).—Last seven segments of trunk with tergites and sternites.

Larger Structures of Tail.

Tail Segments (Abdominal Segments).—Epimera (Pleura); telson.

Appendages of Trunk.

Sensory and Head Organs.—Eye with pedicle (stalk), ocular papilla, and cornea (visual part). Antennule with peduncle (propodite) and flagella (lashes or setæ). Antenna with basal portion, basal scale, peduncle of flagellum (propodite), flagellum (lash).

Organs of the Mouth.—Epistome or lip. Mandible with body supplied with cutting and molar parts, palp. 1st and 2nd Maxillæ with basal and masticatory parts, palp and exognath. Maxillipede with basal part and palp and exopod.

Trunk Limbs, or Legs (Thoracic limbs).—Seven pairs of limbs or legs with endopodites, exopodites, epipodites, gills; breeding lamellæ in females; in males, opening of genital organs. In females, brood pouches and ovisacs.

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Appendages of Tail.

Tail Limbs (Abdominal Appendages).—Five pairs of Pleopods in females all constructed alike with basal joint (propodite) and two swimming plates or lashes (endopodite, exopodite); pleopods of first two pairs in males, modified for sexual purposes, tip of first pair supplied with "coupling hooks" for hanging spermatophores on females. Uropods or last tail limb (abdominal appendages) with basal joint (propodite) and supporting two plates (endopodite and exopodite), inner and outer branches making, together with telson and its appendages, tail fan (tail flap or tail)

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DESCRIPTION OF GENERA AND SPECIES.

Order PODOPHTHALMIA.

Sub-Order SCHIZOPODA.

Family LOPHOGASTRIDÆ.

Genus TEALLIOCARIS gen. nov.

Generic Characters.—Body moderately long and slightly applanated. Integuments generally firm and chitinous and only slightly pitted or grained with a slight wrinkling. Carapace large, nearly half the length of the body, and only loosely covering the seven trunk segments, and externally more or less provided with longitudinal keels. Rostrum spear-shaped, three-edged, and denticulated. Hinder part of carapace never produced into backwardly-directed spines. Caudal segments moderately wide with moderately large single lobed epimera. Eye well developed, large, and with papilla issuing from the pedicle. Antennular peduncle moderately long and slender, the flagella being short and of nearly equal length. Antennal scale caridean in construction and the flagellum very much longer and more massive than the outer flagellum of the antennule. First pair of legs much more massive than the succeeding ones, which are slender and nearly uniform. Branchiæ given off from the bases of all the seven pairs of legs, with lobate sternal branches. Telson large and constricted near tip, with a lobate flattened termination, and set on each side by a small articulated plate-like accessory swimmeret. Uropoda caridean in structure, and not as long as the telson.

The name of the genus is designed to show regard for my old chief, the Director of the Geological Survey, Dr. J. J. H. Teall, whose name I have associated with the Greek word for shrimp to distinguish it from the recent genus of sea anemones named *Tealia*.

TEALLIOCARIS LOUDONENSIS sp. nov. Pl. I., figs. 1-7.

As the collection contains better preserved specimens of this form than of any other of the genus, it may be as well to describe the species in considerable detail, since

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it affords the best evidence that the group to which it belongs finds its place in the Lophogastridæ of G. O. Sars, a family considered by him to be at the head of the great sub-order Schizopoda. Of the four genera described by Sars[1] as constituting the family, the forms about to be described are most nearly allied to *Gnathophausia*, which they closely resemble, though they differ from it in many important particulars.

Specific Characters.—Integuments nearly smooth or only slightly pitted. Body more elongated than in the other species of the genus and not so much flattened. The median longitudinal keel does not reach the posterior margin of the carapace, and none of the keels are denticulated or crenulated. The tail is almost free from longitudinal keels.

General Description.—The general length of the body from the tip of the rostrum to the end of the telson is, on an average, about 30-32 mm. The form is elongated and moderately slender, but not so much so as in *Gnathophausia*, the females being slightly more robust than the males. The body is somewhat applanated, which causes it to be fossilised so as to be generally seen back upward. The integuments are strong and chitinous, though thin and ornamented in their thicker parts with a minute pitting and slight wrinkling, and also with broad marginal bands and pronounced longitudinal keels. In most of the specimens the chitinous nature of the test is disguised by its being calcified or phosphatised and sometimes filled in with galena. The calcification may have begun during life. The other processes seem to have taken place during decay and fossilisation. In some specimens green nodular grains are found which suggest the presence of glauconite. This filling in of the test is not altogether a disadvantage, as it has helped to keep some of the organs from being flattened out, and when it is partial, as it sometimes is, it allows of some of the organs being seen through parts of the test which have not been thus affected, so that one is often able to study the sternal arrangements, through the almost transparent carapace, which otherwise would be hidden by it.

The trunk, which makes up half the length of the body, if we consider the eyes to be dorsal structures and not modified limbs, is built up of thirteen segments each bearing a pair of bi-ramose limbs. The first six are more or less confluent and are in more or less vital attachment with the carapace, their limbs being specially modified to perform the function of sensory and mouth organs. The remaining seven trunk segments, although more or less fused together, are well marked off from each other by strong infolds of the test on the sternal parts, thus forming a very rudimentary endophragmal system, while the dorsal part of each segment is quite covered in, but

[1] G. O. Sars. "Report on the Schizopoda," Results of Voyage of H.M.S. Challenger, 1873–76.

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there is no direct attachment to the carapace. The last trunk segment is not so firmly attached as the rest, and appears to have been slightly movable. Each of these segments bears a pair of similarly constructed biramose limbs identical in structure and function with those of *Gnathophausia* and bearing similar gills (fig. 7[A]), and, in the case of the females, similar breeding lamellæ (fig. 6). The bases of the limbs are set wide apart, thus necessitating the wide sternal plates so characteristic of this group of Schizopods (figs. 1, 3, 5, 7[A]). Each plate has depressions for holding the sternal branches of the gills which pass inwards from the base of the limbs, but do not meet at the mid-line. A raised triangular area is therefore left with its base abutting on the strengthened anterior margin and its apex in the mid-line near the posterior margin. A median conical boss, hollow within, rises upon this triangular area,[1] the whole structure doubtless affording attachment for strong muscles. So firm are these sternal plates and arches that they invariably show up through the carapace in flattened specimens in such a manner as to suggest that they were more strongly constructed than the dorsal parts and the carapace combined. In the males, the external genital openings are situated on the sternal part of the last trunk segment, upon papillae which rise out of crateriform pits just behind the insertion of the base of the limbs (fig. 7[A]).

The carapace (fig. 2), which is subquadrate in form, broader behind than in front, with rounded off postero-lateral angles and hollowed out posterior margin, is well arched and covers the backs and sides of all the trunk segments except the dorsal portion of the last one, and is, as already stated, in vital attachment with the anterior ones, but is only loosely folded back over the last seven or eight, and forms with its side lappets a protective covering for the upwardly-directed branches of the gills, as in *Gnathophausia*. It is divided into two unequally sized areas by a distinct cervical fold which begins at the lateral margins near the antero-lateral angles, and, passing inwards and backwards, becomes V-shaped. The carapace is strengthened by seven longitudinal keels in addition to its thickened lateral and posterior margins. The median or ridge keel is flanked on each side by a nearly parallel dorso-lateral keel, while the four remaining keels, two on each side, are placed not far above the lateral margins, the whole arrangement being almost a counterpart of what takes place in *Gnathophausia*. All the keels are interrupted by the cervical fold, and some are not carried forward on to the area in front

[1] Since writing the above, I have had the opportunity of examining a remarkably well preserved specimen belonging to Mr. J. Bowie, showing the ventral aspect, which leaves little doubt in my mind that these conical hollow bosses held luminous organs like those found in a similar position on the tail segments of the recent *Nictiphanes*, with which I have compared them.

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of it. None of them have been observed to be serrated or crenulated. The smaller area in front of the cervical fold shows an arched gastric portion surmounted by the median keel, which is continued forward into a slender rostrum about one-third of the length of the trunk. The rostrum is further strengthened by two flanking keels, and has at least one spine on each side of the median terminal one. The lateral angles made by the confluence of the rostrum with the anterior margin of the carapace are well rounded off to form orbits, and there is a supra-orbital spine marking the termination of that part of the dorso-lateral keel lying in front of the fold. This keel is also placed upon an embossed eminence. Chiefly owing to the crushing and crowding of the parts during fossilisation, no evidence has been obtained as to whether there is an antennal spine, though certain indications seem to suggest its presence. The edges of the carapace in the space between the position of the antennal spine and the fold seem to be puffed out, and as seen from beneath, as in fig. 5, M. 4821^{E},* form a little recess within, similar to that seen in *Gnathophausia*, and doubtless for the same purpose, viz., to hold the peculiar exognathite of the second maxilla, remains of which are preserved in specimen M. 4807^{E} (fig. 7^{A}).

In the larger area behind the cervical fold the median keel occurs near the anterior end, only being most pronounced just behind the fold and dying down rapidly when traced backwards, and disappearing altogether before one-third of the distance to the posterior margin is reached. There is no appearance of either the keel or a median spine at the posterior margin. The dorso-lateral keels are most pronounced in front just behind the fold, and can be traced right back to the posterior margin. The two lateral keels on each side begin at the fold and, diverging gently for a time, converge towards the rounded-off postero-lateral angles of the carapace. Behind the cervical fold the carapace is edged with a handsome fluted band which passes round the backwardly-directed, rounded lappets and the concave posterior margin. So deeply cut out is this posterior part of the carapace that while the posterior angles lap over the epimera of the first tail segment, the whole breadth of the last trunk segment is left bare in the mid-line of the back. As stated above, no trace of median backwardly-directed spine has been observed.

The tail (figs. 1, 3, 4, 5), which is about the same length as the trunk, is well arched and almost cylindrical, but tapering backwards, and is constructed, like that of the true caridea, of six segments forming complete rings with epimera, and a seventh terminal one or telson in which the anus is situated (figs. 3, 4, 5), and which has therefore a right to be considered a true segment and not a medial appendage. According to this

* Geological Survey registration number.

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view, the segments entering the tail, counting backwards from the first or antennule-bearing segment, number from 14 to 20 consecutively. The first segment is very short. There is a sudden increase in the length of the second, and from thence there is a gradual increase of each segment in succession up to and including the anterior part of the sixth, where there is a sudden expansion accompanied by an applanation of the segment for the attachment of the tail fan. To allow of the folding of the tail, all these segments are well facetted on the anterior margins of the back and sides above the pivots which are placed at the bases of the epimera. For the same reason the sternites become very short in the mid-line (fig. 3), M. 4848[E], while the epimera themselves generally overlap each other in turn from before backwards, the anterior margin of each being facetted for the purpose (figs. 3, 4). The outcome of this arrangement is that when the tail is extended it lies much in the same straight line with the trunk, and when flexed it rolls up so that the posterior end of the animal makes a complete semicircle.

The portions of the dorsal plates exposed when the tail is extended are bordered along their anterior margins, and there are sometimes traces of a median longitudinal keel upon the anterior parts of the third and sixth segments by the border giving off a backward projection in the mid-line.

The epimera are well developed (figs. 3, 4) and consist of only one lappet on each side, in this respect differing from those of *Gnathophausia* and resembling those of *Lophogaster* and *Ceratolepis*. They are directed downwards and backwards and end in blunt points. Those of the first tail segment are, as already stated, overlapped by side lappets of the carapace and are comparatively small. Their posterior margins overlap on to the epimera of the succeeding segments, which are much larger. As already stated, this order of overlap is maintained up to the sixth tail segment, the epimera at the same time becoming in turn less deep but more bent backwards. The epimera of the sixth segment are not carried so far back as the rest, and only extend to where the tail begins to expand. There is no evidence that the epimera on the two sides of this segment are confluent at their base, as in *Gnathophausia*, but it is difficult to obtain specimens which show the ventral aspect, and owing to the flattening which takes place towards the back end of this segment it seldom becomes fossilised sideways. The evidence obtainable is rather against the view of their being confluent. The telson is elongated and somewhat heart- or shield-shaped. Viewed from above (figs. 1, 3), it is tumid towards the base and expands slightly for a short distance from the articulation, then it flattens and tapers, at first gradually, and then more rapidly, till at about three-fourths of its length it becomes suddenly constricted, after which it once more expands

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into an elongated flattened plate, which is somewhat indented in the mid-line, and is corrugated radially and set with strong bristles round its hinder margin. The anterior part of the telson, at a short distance from the articulation, developes a median furrow which divides the tumid portion into two areas and is carried back to the constricted part. From behind each tumid area there is continued a ridge surmounted by a keel which, diminishing as it passes backwards, terminates at the angle made by the constriction. The external edge (fig. 3) of this part of the telson is fringed with strong and longish, even-sized bristles which show no tendency to have recurring finer and stronger filaments, as in *Gnathophausia*. Several specimens (figs. 1, 3, 5) show that flattened lobes fringed with setæ were articulated with the telson at its constriction, which evidently assisted in forming the tail fan, like those shown in the American *Anthrapalæmon gracilis*[1] of Meek and Worthen. With the exceptions above mentioned, the telson of this species is constructed on almost identical lines with that of *Gnathophausia*. The terminal lobe appears to be a feature of the ancient Lophogastrids as it occurs in other genera, as will be shown in the sequel.

The eye (figs. 1, 3, 4, 7, 7a) is large and nearly always directed outwards. The stalk is very narrow at the base, and after an articulation it suddenly expands into a cup-shaped pedicle, the margin of which is always undulating and so often notched at the same place in different individuals when crushed that the cornea appears to have been slightly pear-shaped or lobed. In a great many specimens there has been observed a projection proceeding from the outside of the pedicle on the side of the eye next the rostrum. In fact, it is invariably to be observed if the eye is sufficiently well preserved the right way up to show it. There can be no doubt that it represents the ocular papilla, the relic of a temporary functional larval eye such as appears in *Gnathophausia* and other Schizopods. In the present species it is moderately large compared with the size of the eye, and is bent round and directed forwards (figs. 4, 7A). The antennules (figs. 1, 3, 4, 5) consist of a massive elongated three-jointed peduncle measuring over 5 mm., the last joint of which is ridged along its inner margin and well set with setæ, and extends beyond the tip of the rostrum. This joint gives off two stout, but comparatively short, flagella a little longer than the peduncles, the inner flagellum being somewhat the stouter and longer, in this respect differing widely from the recent Lophogastrids in which this branch of the antennules is more massive than the flagellum of the antenna. The specimens are not sufficiently well preserved to show whether the peculiar scale-like sensory organ that is found between the bases of the flagella occurs in this species or not. In nine cases out of ten the terminal joint of the propodite is pressed against the

[1] Geol. Surv. Illinois Report, 1866, vol. 1, p. 407, pl. xxxii, fig. 4 a.b.c.

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setigerous tip of the basal scale of the antenna so as to render the recognition of such an organ impossible, even though it were present.

The antennæ are usually preserved in such a way that the basal joints are concealed. The opening of the green gland has, therefore, not been observed. The basal scale is long (5 mm.) and extends beyond the peduncle of the antennules, and is constructed like that of an ordinary caridean. Its outer thickened border ends in a spine, and the terminal lobe which is attached by a transverse suture is radially corrugated and set with a fine fringe of setæ. The inner edge is also thin and corrugated and fringed with setæ. The peduncle of the flagellum is composed of three joints, and the last is usually bent off at about one-third of the length of the basal scale. The lash is massive and long, over two-thirds the length of the body. In the specimen M. 84^{F}, from which fig. 1 is taken, the length of the body is 32 mm.; that of the lash measured along its curve is 25 mm.

The epistome or anterior lip (figs. 3, 7^{A}) is three-lobed and galeate.

The mandible is made up of the usual body or palp. The body is large, but owing to the specimens being usually crushed, the details of the molar portions and cutting edges are obscured, although they are shown in figs. 1, 3, and 7^{A}. The palp (figs. 1, 3) is pediform, and consists of three joints, and is often well preserved owing to its position.

The hypostome or posterior lip (figs. 3, 7a) is moderately large and bilobed.

The maxillæ consist of the usual two pairs. The first pair are probably constructed as in *Gnathophausia*, for an organ with a similarly ciliated palp is found loose in specimen M. 4807^{E} (fig. 7^{A}). The opposite corresponding one is also displaced and lies a little in advance and on the other side. These have evidently been broken away and displaced, as all the organs in advance of the second maxillæ manifestly are. If these displaced organs represent the first maxillæ, then they are much more strongly set with blunt bristles or teeth along the outer edges of the masticating lobes than those of *Gnathophausia*. The second pair of maxillæ are much as they are in *Gnathophausia*. The two- or three-jointed palp is even more pediform than in that genus. Traces of the peculiar reniform ciliated exognathite also occur in this wonderful specimen M. 4807^{E} (fig. 7^{A}). Taken in consideration with the emarginated recess already mentioned as occurring in the anterior part of the carapace, as shown in specimen M. 4821^{E} (fig. 5), a strong link in the chain of evidence is added to connect up these ancient forms with the recent Lophogastridæ. The peculiar luminous organ which accompanies this set of appendages in *Gnathophausia* has not been observed.

The endopodite of the maxillipede is of the same general tumid form as in *Gnatho-*

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phausia, and consists of five joints set with strong setæ and curved inwards in the same manner; but in the present species the limb is relatively larger and longer than in the recent genus. The base of the limb is obscure, and the connection of the limb with the peculiar epipodite also cannot be observed. A structure which is probably the extremity of the epipodite is seen in the specimen from which fig. 7[A] is taken. It is acutely triangular and pitted in a manner like that organ in *Gnathophausia*.

The maxillipedes are followed by seven pairs of limbs corresponding to the trunk segments from 6–13 inclusive. All these limbs are constructed on the same principle and, with only some slight modifications, the same parts enter into each. The endopodites are all pediform, and consist of seven joints. As in *Gnathophausia*, the anterior limbs are stouter than the hinder ones, and there is along with this a difference in the proportional length of the component joints. As in *Gnathophausia*, they are laterally compressed and set along their inferior edges with setæ. In the first pair, which are the most massive, the inferior edge is closely and evenly set with strong setæ, whereas in the hinder ones, to judge from the pits out of which they spring, they seem to have been arranged in tufts. The terminal joints appear to have been in all cases spatulate, and no terminal claw has been observed. The structure and arrangement of the endopodites of all these limbs seems to fit them better to form a great straining apparatus for the entrapping of minute organisms rather than for crawling or swimming. The limbs all flex in such a manner as to suggest that they are intended to bring the objects of their capture within reach of the palps of the mouth organs which, in the recent Lophogastrids, are abundantly set with sensory hairs.

The exopodites which spring from the base of each limb consist of a strong, very muscular basal joint surmounted by a powerful many-jointed swimming lash fringed with setæ on each side, the comparative length of the two branches of each limb varying from 2–1 or 3–2, the endopodite being in every case the longer.

Only the sternal branches of the gills have been observed, the trunk arteries of which appear to be given off from the bases of the legs (fig. 7[A]). To judge from the imperfectly preserved specimens at command, where the blood vessels are either collapsed or split up the middle, the arrangement of the branches and lobules is more like that which takes place in *Eucopia* than in *Gnathophausia*, and this is borne out by the more perfectly preserved gills in the very nearly allied *Tealliocaris woodwardi* (pl. ii., fig. 4[A]). In the females the bases of the limbs give off breeding lamellæ (figs. 4, 6), and it is probable that all the seven pairs were supplied with them. They are even better displayed in specimens of the closely-related *T. woodwardi* (pl. ii., figs. 1, 3, 3[A]) in the form of a series of over-

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lapping plates with rounded ends and finely ciliated borders. They are very delicate in texture, and are usually much wrinkled in their fossilised condition. The external openings of the genital organs in the male, as already stated, open on a papilla situated on the sternal part of the last trunk segment at the base of the limbs (fig. 7[A]). The caudal limbs (figs. 4, 7[A]) on the first five tail segments in both sexes are in the form of powerful natatory organs each having a very strong muscular base and terminating in spatulate many-jointed blades set along their edges with strong setæ. As in *Gnathophausia*, these are all uniform, and none of them are specially modified for sexual purposes, although the manner in which the first pair are applied to the sterna of the trunk in fig. 7[A] suggests that they may have assisted in directing the male products to reach the marsupium of the females, as spermatophores are not in use in this group of Schizopods. The uropods on the sixth tail segment are flattened out in the usual manner to act along with the telson as a caudal fan (figs. 1, 3, 4, 5). They consist of a very short and flattened basal part and two terminal plates, and are quite caridean in structure. The outer plate is strengthened on its outer margin and terminates in a decided spine, the inner part being more web-like and corrugated and edged with setæ. A transverse suture crosses the plate from the base of the spine, separating it from the terminal lobe, which is fringed along its outer margin by strong setæ. When the terminal lobe is broken off, as in fig. 1, the margin of the suture is seen to be ciliated with fine setæ. The inner plate is tongue-shaped, keeled near its mid-line, and fringed with setæ on both sides as well as round its apex. Both plates seem to be of about the same length, and do not extend backwards as far as the tip of the telson.

The appendages of the telson, as already stated, consist of flattened lobes fringed with setæ which are articulated with the telson at the constriction in front of the terminal lobe, and seem to be characteristic of several of the genera entering into the family.

The specific name is derived from the ancient district of Loudonia, Haddingtonshire, being still known as Eastlothian.

Locality.—All the specimens of this genus are from dark calcareous shales exposed on the seashore near Gullane, Haddingtonshire.

Horizon.—Wardie Shales, Oil Shale Group, (Scottish) Calciferous Sandstone Series.

Collector.—A. Macconochie.

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TEALLIOCARIS WOODWARDI (R. Etheridge, jun.). Pl. II., figs. 1–6.

1877. *Anthrapalæmon? woodwardi* R. Etheridge, jun., Quart. Journ. Geol. Soc., vol. xxxiii., p. 863, pl. xxvii.

1879. *Anthrapalæmon woodwardi*, R. Etheridge, jun., Quart. Journ. Geol. Soc., vol. xxxv., p. 468, pl. xxiii., figs. 4–9.

Among the material obtained from Gullane by Mr. Macconochie from which *T. loudonensis* is described, there are a few well-preserved specimens belonging to this present form which show that this species is closely allied to *T. loudonensis*, and therefore is not a macrurous Decapod, but like it belongs to the Lophogastridæ. The study of the new specimens naturally led to a re-examination of those used by Mr. Robert Etheridge, jun., for his description of the species. This latter material forms part of the Geological Survey Collection, and the recent examination has necessitated some addition to the description given by my old colleague.

Specific Characters.—Smaller form than *T. loudonensis*, relatively wider carapace and thinner tail. Integuments slightly pitted or wrinkled. The longitudinal keels are

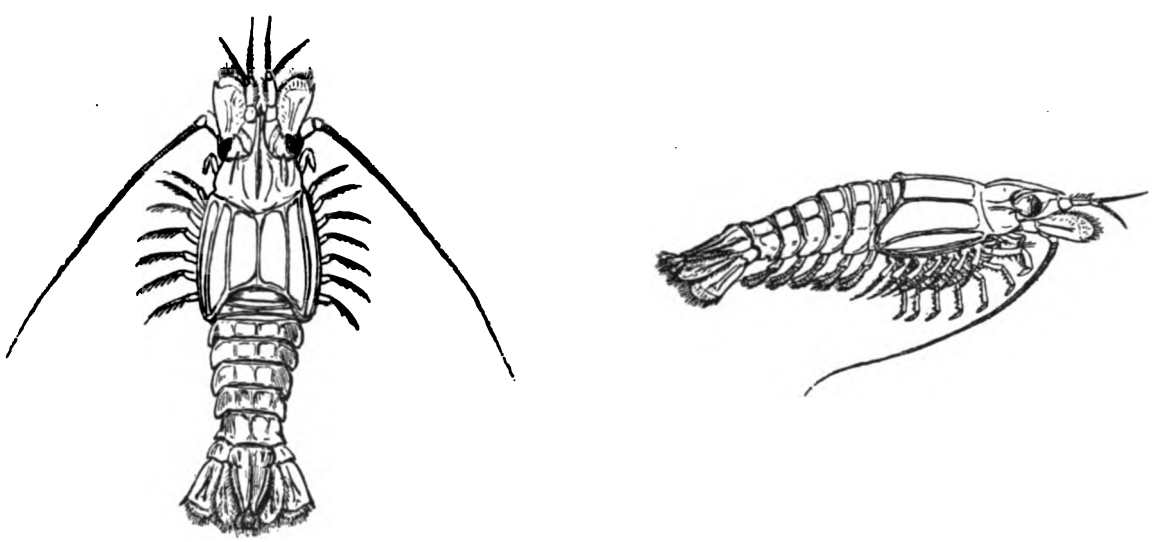

Fig. 1.—Restoration of *Tealliocaris woodwardi*, mag. 4 diameters.

not crenulated, and all reach the posterior margin of carapace. Three of the keels, the median and two lateral ones, are continued as longitudinal ridges on all the tail segments, and the last segment and the telson are considerably ornamented.

General Description.—This is one of the most beautiful species of this group, and

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approaches most nearly in form and characters to the recent *Gnathophausia*. It is about the smallest species of the genus, averaging about 15-20 mm.; but full grown specimens, as shown by the well-developed breeding lamellæ, are found even smaller. In form it greatly resembles *T. loudonensis*, but is somewhat shorter in proportion, and proportionately wider across the carapace and narrower across the sixth tail segment. The wide carapace generally causes the form to be fossilised so as to be seen back up.

The carapace behaves to the trunk segments as in *Gnathophausia* and in the former species, that is, it only loosely covers the last seven trunk segments, and when in place leaves the dorsal part of the last segment quite bare. It is ornamented with all the seven longitudinal keels in addition to the thickened marginal bands. All the keels are interrupted at the well-marked cervical groove. The median keel is continued into the rostrum, which is long and is flanked by side keels and ends in spines as in *T. loudonensis*. The dorso-lateral keel is also continued in front of the interrupting fold and ends anteriorly in a supra-orbital spine. The dorsal integuments of the trunk segments, with the exception of the last, are quite thin and almost membranaceous. The last segment forms a complete ring, and seems to have been more loosely attached than the others. The sternites of the seven leg-bearing trunk segments are strongly built and the first is narrow and wedge-shaped, the others becoming in turn wider and wider, the whole forming the wide sternum so characteristic of the Schizopoda, and especially of this group. In their form and arrangement these sternal plates are individually almost the counterpart of the corresponding structures in *T. loudonensis*, and, as in that species, the sternal arrangements are usually to be seen through the carapace.[1]

The tail is shorter in proportion to the trunk than in the type species. The individual segments bear much the same proportion to each other as in it; but the transverse strengthening bands are more pronounced, and there are longitudinal keels on each segment in continuation of the line of the median and dorso-lateral keels of the carapace. In the hinder segments of the tail the panel-like spaces enclosed within the areas bounded by the smooth transverse bands and the longitudinal keels are somewhat embossed, the integuments are pitted and wrinkled into a sort of pattern (figs. 1, 2); but this is not carried to such an extent as in some other forms belonging to the group.

The eye is larger in proportion than in the former species, and, as the stalk is short, the taper is necessarily very rapid. The visual portion or cornea is large, and was probably pear-shaped. A comparatively large ocular papilla has been observed in several specimens (figs. 4, 6) to proceed from the pedicle on its inner aspect. The

[1] Similar bosses occur on the sternites of this species and those found on *T. loudonensis*, and doubtless had a similar function, viz., that of holding luminous organs.

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antennules show the same massive peduncle extending beyond the tip of the rostrum and the basal scale of the antenna, and terminating in two short many-jointed lashes of nearly equal length. The antennal scale is a little more expanded and shorter in proportion than in the type species, and, like it, the antennal lash, to judge from the portions preserved (figs. 3, 5), was massive and long compared with those of the antennule, in this respect differing widely from the recent Lophogastrids. The mandibles are usually too much crushed to be studied, but their position is generally well shown in consequence. The palp, which often extends into the surrounding sediment, is often seen in specimens fossilised sideways to be three-jointed and pediform. The maxillæ have not been seen in a fit state of preservation for study. Of the maxillipedes, only what are probably the detached endopodites have been observed (fig. 1), M. 4816^{E}, the three last joints of which are similar to those of the type species. Of the seven pairs of legs, the endopodites have all been observed. They are much as in the type species, but are all proportionately shorter and thicker. The exopodites, as in the former species, have the strong muscular basal joint, and terminate in strong ciliated many-jointed swimming lashes (figs. 1, 4). The epipodites consist, in the females, of breeding lamellæ attached to the bases of the last seven trunk limbs. These are membraneous, round tipped, and edged with ciliated borders, and so large in flattened-out specimens that they often project beyond the edges of the carapace as imbricating finely-corrugated plates (figs. 3, 3^{A}), M. 4844^{E}. The gills (figs. 3, 3^{A}, 4) are as in the former species. These are seen to be constructed on the same principle as in *Gnathophausia* (fig. 4^{A}), M. 4246^{B}, the branch arteries ending in lobulated blood sinuses, but the branch arteries do not seem to be given off at such regular intervals as in that form, and thus in some respects resemble those of the nearly allied *Eucopia australis* Dana, as figured by G. O. Sars in his monograph on the Schizopoda of the Challenger Expedition.

The caudal limbs (figs. 3, 5) are constructed as in *T. loudonensis*, and were apparently spatulate in their terminal swimmerets. The uropods of the sixth tail segment are like those of the former species, but a little broader in proportion. The telson differs considerably from *T. loudonensis* in having a median crest extending back to near the constriction. It has also side keels or crests ending at the articulations of the two accessory flattened swimmerets with which, like the former species, it was supplied. It also ends in a fimbriated mesial lobe notched at the end, and set along its posterior border by strong setæ or spines.

Remarks.—It may be as well to make some further remarks about the specimens. Fig. 1 shows one of the best preserved specimens from Gullane shore, magnified 6 diameters. It is fossilised with its back up, but it is fortunate that the carapace is

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sufficiently transparent to allow of the sternal organs and limbs to be seen through it, so that one can make out the palps of the mandibles, the wide sternal arches, the endopodites and exopodites of the limbs, as well as the breeding lamellæ, from which it is evident that it represents a full-grown female. Figs. 3, 3^{A}, are also from Gullane, and represent another adult female. Fig. 2 is from a specimen M. 4249^{B} from Tweeden Burn, near New Castleton, Roxburghshire. It is one of those figured by R. Etheridge, jun., for his description of the species.[1] It shows the longitudinal keels on the carapace and the continuation of some of these as ridges on the tail better than the Gullane specimens. It also shows the nature of what was doubtfully considered to be the remains of a large chelate limb of a Decapod. The massive first leg on the right side is seen to be overlaid by the antennal scale and a broken part of a carapace of a small specimen of the same species. There can be no doubt of the Schizopod nature of the specimen, as the broken lashes of some of the exopodites are seen emerging from beneath the edge of the carapace on both sides of the carapace. Fig. 5, M. 4249^{B}, is also one of those figured by R. Etheridge,[2] and occurs on the same slab with figs. 2, 6. This is evidently a male, and shows that they were of slightly more slender form than the females. It shows the antennules and antennæ, the large eyes with the ocular papilla, the curved rostrum, and longitudinal keels of the carapace interrupted by the cervical fold. The palps of the mandibles and several of the trunk limbs, with both endopodites and exopodites, are also well shown, as well as the details of the tail segments with the longitudinal ridges, also the pleopods with spatulate termination, and the nature and arrangement of the uropods. The telson with its central crest which, seen edgeways, is shown to be slightly crenulated, is also seen to be supplied with accessory swimmerets and to be fringed along its edge with an evenly set row of setæ. This is altogether one of the most elegant and best preserved specimens in the collection. Another specimen from Tweeden Burn figured by R. Etheridge[3] is represented in fig. 4 to show the exopodites of the seven trunk limbs on the left side free from the edge of the carapace, their bases being traceable inside it, the bases of the corresponding limbs of the right side being shown within the edge of the carapace on the other side of the wide sternites. The exopodites of some of the limbs, as well as several of the breeding lamellæ, are seen on the left side. The chief point of interest, however, is that the sternal branches of several of the gills are well displayed on the right side. The more intimate structure of one of these is shown magnified 20 diameters in fig. 4^{A}.

[1] Quart. Journ. Geol. Soc., 1879, vol. xxxv., pl. xxiii., fig. 4.

[2] Loc. cit., fig. 6.

[3] Loc. cit., fig. 9.

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What appears to be a young specimen of this species, as it is one of several such minute forms that occur on the same slab as figs. 2, 5, and was also figured by Etheridge,[1] is shown magnified 15 diameters in fig. 6, M. 4249[B]. The carapace is larger in proportion to the tail than in the adults. The eyes are particularly large and the ocular papillæ very distinct. The keels on both the carapace and tail are very marked, and on the portions visible the characteristic features of the present species are quite apparent. The limbs, however, are all hidden.

Locality.—Shore near Gullane, Haddingtonshire, and Tweenden Burn, near New Castleton, Roxburghshire.

Horizon.—Oil Shale Group, and Cementstone Group, Scottish Calciferous Sandstone Series.

Collector.—A. Macconochie.

TEALLIOCARIS WOODWARDI, var. Pl. II., figs. 7–9.

Specimens of a well-marked elongated variety occasionally occur. Fig. 7, R. 1709, represents the back view of the trunk and part of the tail of one specimen, natural size. Fig. 8, R. 1717, shows the same view of both trunk and tail of another specimen, somewhat enlarged. The carapace shows the characteristic longitudinal keels all reaching the posterior margin. The eyes, as well as the antennular and antennal system, are also well seen. The tail shows the median ridge upon all its segments, and the telson, its terminal lobe and accessory swimmerets.

Locality.—Chattlehope, Rede Water, Northumberland.

Horizon.—Cementstone Group (Tuedian), Scottish Calciferous Sandstone Series; English Carboniferous Limestone.

Collector.—J. Rhodes.

TEALLIOCARIS ETHERIDGEI (Peach). Pl. III., figs. 1, 2.

1882. *Anthrapalæmon etheridgei* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 76, pl. viii., figs. 3–3g.

The collection contains a large number of specimens of this well-marked species in addition to those figured by me for the original description. The light shed upon this form from the study of the well-preserved specimens of the species already described makes it plain that the present form is another species of the same genus, and that I

[1] Quart. Journ. Geol. Soc., 1879, vol. xxxv., pl. xxiii., fig. 7.

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was quite wrong in assigning it and nearly allied forms to the macrurous Decapods. The wide sternal arches so characteristic of this group of Schizopods are almost invariably shown in the compressed specimens, as in fig. 1, which is a reproduction from the original drawing for fig. 3b of plate viii. of vol. xxx. of the Transactions of the Royal Society of Edinburgh. It also shows the characteristic telson of this group. Fig. 2, also a reproduction of fig. 3 of the original description, shows the longitudinal keels on the carapaces placed as in *Gnathophausia*. The chief points in which this species differs from those just described are its much greater size, which averages from 30–40 mm. in length, the nature of its integuments, which have a distinct grained pattern upon all the dorsal parts where friction does not come into play, and in having serrations on the median longitudinal keel, both in front of and behind the cervical fold and on the edges of the rostrum. From *T. loudonensis* it differs in having the median keel of the carapace carried right back to the posterior margin, while it differs from *T. woodwardi* in the tail having a trace of the median longitudinal keel only upon one of its segments, while, in the latter form, three distinct keels are found on the tail segments.

Locality.—River Esk, Glencartholm, Langholm, Dumfriesshire.

Horizon.—Scorpion-bed, Calciferous Sandstone Series.

Collector.—A Macconochie.

TEALLIOCARIS ETHERIDGEI, var. LATA Peach. Pl. III., figs. 3, 4.

1883. *Anthrapalæmon etheridgii*, var. *latus* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 513, pl. xxviii., figs. 4–4b.

Remarks.—This variety is in all other respects like *T. etheridgei* except that it is shorter and broader in its proportions. Its breadth compared with its length is as 1 to $2\frac{1}{8}$, when in the latter it is as 1 to 3. The carapace is broader than long, while that of *T. etheridgei* is the reverse.

This form occurs in the Scorpion-bed at Langholm along with *T. etheridgei* in about the proportion of one of the former to one hundred of the latter.

Locality.—Glencartholm, Langholm, Dumfriesshire.

Horizon.—(Scottish) Calciferous Sandstone Series.

Collector.—A. Macconochie.

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TEALLIOCARIS ROBUSTA sp. nov. Pl. III., figs. 5–8.

Specific Characters.—Strong robust form. Length, 30–40 mm. Integuments firm and ornamanted with pits, and granulated. The seven keels of the carapace crenulated. No ocular spine, but a blunt one at the anterior angle of carapace. A slight peak backwards in the mid-line of the posterior margin of the carapace suggestive of a median spine. Longitudinal ridges of the tail very marked and sharp and crenulated on the hindermost segment and telson.

General Description.—This species strongly resembles *T. woodwardi*, especially in the distribution of its longitudinal keels on the carapace and the longitudinal ridges on the tail, but differs from it in its much greater size and more robust proportions. It is altogether more strongly built and its integuments are more embossed and its longitudinal keels and transverse bands deeper and broader, and the keels are distinctly crenulated along their crests. A cast of the interior of the carapace is illustrated by fig. 5, M. 2752^{E}, which, though it has been torn in two before being embedded, shows its characters well, viz., its great width compared with the length, the seven crenulated longitudinal keels behind the well-marked cervical fold, the blunt inwardly-directed spines at the antero-lateral angles, the absence of an ocular spine, the rostrum, relatively wider at base than in the already described species, but surmounted by the sharp crest of the ridge keel, and the backward peak in the mid-line of the posterior margin. All these features are also shown in fig. 6, which is a drawing of the inside of the carapace, the peak in the mid-line of the posterior margin being even more suggestive of a blunt spine than in the former one. The tail segments and part of the telson flanked by the uropods are shown in fig. 8 enlarged about 3 diameters. The details are much like those of *T. woodwardi*, but with every structure exaggerated. The strong transverse bands, rising abruptly from the rolling facets to ensure locking of the tail joints when that organ was extended, the strong and backwardly-set epimera, and the median and lateral keels, as well as the embossed panel-like compartments confined within these structures, are all suggestive of great muscular power. A view of the underside of part of the trunk and tail is afforded by the specimen shown in fig. 7. At the anterior end two joints of the peduncle of the right antennule are seen partly covered by portions of the antennal scale, as well as the peduncle and part of the massive antennal lash. The broad sternum, narrowing in front and showing parts of at least seven segments, is well displayed with the bases of four of the limbs still articulated with it on the right side of the animal, and one on the left. The terminal joints of two of the exopodites and the basal joint and lash of one of the exopo-

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dites are seen just beyond the right margin of the carapace. The sternite of the first tail segment indicates that the bases of the pleopods were not placed so far apart as those of the adjacent trunk limbs.

Locality.—Whiteadder Water, near Duns, Berwickshire.

Horizon.—Cementstone Group (Tuedian), Scottish Calciferous Sandstone Series.

Collector.—A. Macconochie.

TEALLIOCARIS ROBUSTA, var. nov. Pl. III. figs. 9–12.

Specimens of a smaller and more slender form, that may be considered as a variety of this species, were once submitted to me for description by the late Mr. Coutts of Glasgow. At his death they were acquired by the Royal Scottish Museum, Edinburgh, and now form part of that collection in Edinburgh.

General Description.—The inside view of the carapace of one of the specimens is shown, natural size, in fig. 10, the outside of the right half, also natural size, in fig. 11. From these, it is apparent that it agrees with the carapace of the parent species in the arrangement of the longitudinal keels, in the blunt spine at the antero-lateral angles, and in the backwardly-directed peak in the mid-line of the posterior margin. On the other hand, it differs from it in general form, being narrower and longer proportionately, in the keels and lateral margins being either smooth or only so slightly crenulated that this feature has escaped detection, in its narrower rostrum, and in being more hollowed out behind. The carapace exhibits the same tendency to split along the mid-line as that of *T. robusta*, and, like it, to show its interior aspect. This latter point is worthy of notice, for it is evidently owing to the very prominent keels and the rough pitted integuments of the dorsal side giving it a greater hold of the embedding rock than the smooth inner side, that, when the rock is split open, the break takes place along the inner side of the fossil.

Part of the carapace and the greater part of the tail are shown natural size in fig. 9, and the last segment and tail fan, magnified four diameters, in fig. 12. These all agree with generally corresponding parts in the parent form, but the proportions are slightly different. The nature of the ornamentation of the embossed parts of the test is the same; but the crenulations on the crests of the ridges are either absent or inconspicuous in the present form. It is perhaps worth observing that the telson shows the characteristic terminal lobe and the accessory swimmerets, broken away in specimens of *T. robusta*.

Remarks.—The specimens from which the characters of this variety have been

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made out are from a higher horizon of the Lower Carboniferous Rocks than those in which the remains of *T. robusta* were obtained. It is probable that when better preserved specimens of both forms are available they may be seen to belong to distinct species. In the meantime the evidence is not sufficient to show that such is the case.

Locality.—Calderwood Cementstone Quarry, East Kilbride, Lanarkshire.

Horizon.—Lower Limestone Group, Scottish Carboniferous Limestone Series.

Collector.—Andrew Patton.

Tealliocaris tarrasiana sp. nov. Pl. III., figs. 13–16.

Specific Characters.—Small form averaging 20 mm., with smooth integuments and without longitudinal keels on the area of the carapace behind the cervical fold, and only showing traces of ridge keels near the extremities of the body.

General Description.—This species is characterised by its very delicate and smooth integuments and its generally slender and elegant form.

The carapace has a distinct V-shaped cervical fold. The rostrum appears to be shorter in proportion than in any other species of the genus. There are traces of the median keel on the rostrum and the gastric protuberance behind it; but it does not reach the cervical fold. As usual, the broad sternites of the last seven trunk segments are generally shown through the overlying carapace in compressed specimens, the form being usually so fossilised as to show back up, from which it may be inferred that it was somewhat applanated. The eyes are moderately large. The antennules show the usual three-jointed peduncle and the two short terminal lashes, the external one being somewhat the longer and more massive. The basal scale of the antenna is largely developed and extends beyond the carapace as far as the end of the antennular peduncle. The peduncle of the antenna is comparatively short, so that the lash usually appears to be bent off at about two-thirds of the length of the scale. The palp of the mandible is visible in one specimen (fig. 13), M. 3158^{c}, but its character is not apparent. The exopodites of seven slender long-jointed legs are shown outside the margin of the carapace on the left side of the creature, and several of them with the proximal joints can be traced within the carapace, but the exopodites, if preserved, do not show without. Some of the joints of limbs are also shown on the right side.

The tail is constructed much as in *T. loudonensis*, but with only the transverse strengthening bands and no ridge keel to any of the six segments. That keel occurs, however, on the telson, which is constricted at the usual place and bears accessory

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swimmerets. The uropods are largely developed and are of the usual caridean character (fig. 14), M. 3181^{c}. An attempt to make a restoration is given in fig. 16, the only structures not exhibited by the fossils figured being the exopodites of the seven trunk legs, some of which, however, have been observed in specimens in the collection that are not figured. Breeding lamellæ have also been observed in specimens from another locality.[1]

Localities.—Near the foot of Tarras Water, Langholm, Dumfriesshire, and White-adder Water, ¾ of a mile below Allanton, Berwickshire.

Horizon.—Cementstone Group, Calciferous Sandstone Series.

Collector.—A. Macconochie.

TEALLIOCARIS FORMOSA (Peach). Pl. III., figs. 17, 18.

1882. *Anthrapalæmon formosa* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., pt. i., p. 83, pl. viii., fig. 8; pt. ii., 1883, p. 512, pl. xxviii, figs. 3-3b.

Remarks.—There are several specimens of this form in the collection. As no new point has been established with regard to this species, two of the figures are reproduced from the Transactions of the Royal Society of Edinburgh, where the description of the species was published. One of these (fig. 17) shows the carapace and the other (fig. 18) shows the tail with its terminal fimbriated lobe so characteristic of this group of Lophogastrids.

The only form that this might be confounded with is *T. tarrasiana*, but the present is a much larger form and more elongated relatively in the tail.

Locality.—Glencartholm, Langholm, Dumfriesshire.

Horizon.—Scorpion bed, Calciferous Sandstone Series.

Collector.—A. Macconochie.

Genus PSEUDO-GALATHEA Peach, 1883.

1883. *Pseudo-Galathea* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 513.

Remarks.—A further study of the specimens belonging to this genus, in the light of G. O. Sars' Report on the Schizopoda brought home by the Challenger, convinced me many years ago that they ought to be classed with Lophogastrid Schizopods rather than with macrurous Decapods, among which I arranged them in my original description published in the Transactions of the Royal Society of Edinburgh.

[1] Specimen M. 2749^{E} (Geological Survey registration number).

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PSEUDO-GALATHEA MACCONOCHIEI (R. Etheridge, jun.). Pl. III., figs. 19-22.

1879. *Anthrapalæmon macconochii* R. Etheridge, jun., Quart. Journ. Geol. Soc., vol. xxxv., p. 471, pl. xxiii., fig. 10.

1882. *Anthrapalæmon macconochii* Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 82, pl. viii., figs. 6–6d.

Remarks.—Several specimens of this well-marked species occur in the collection besides those used by R. Etheridge and myself for the original descriptions. The carapace (fig. 20)[1] with its longitudinal keels and postero-lateral angles produced into long spines, but more especially the ridge running along behind the cervical fold and connecting the dorso-lateral and lateral keels, strikingly remind one of similar arrangements in some species of the recent genus *Gnathophausia* Willemoes-Suhm, as figured and described by G. O. Sars. Fig. 19[2] also shows the relation of the carapace to the tail. Fig. 22[3] shows the anterior sensory organs considerably enlarged, the large short stalked eyes, and the outer branch of the antennule which is the larger, but puny compared with the lash of the antenna, in this respect being like *Tealliocaris* and differing widely from the described modern genera. Fig. 21[4] shows the tail fan with the characteristic terminal lobe and accessory swimmerets. This combination of characters leaves little or no doubt as to the affinities of this species and genus.

PSEUDO-GALATHEA ROTUNDA B. N. Peach. Pl. III., figs. 23, 24.

1883. *Pseudo-Galathea rotunda* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 514, pl. xxviii., figs. 6, 6a.

Remarks.—A specimen occurs among the collection which evidently belongs to this species, although it is even shorter and rounder than those figured. It is figured here (fig. 23), as it throws additional light on the genus. The eyes, antennules and antennæ are much as in *Ps. macconochiei*. The present specimen, however, shows the broad sternites of the trunk so characteristic of this group of Schizopods, and also the proximal joints of at least six of the trunk legs, all of the uniform type and all on the

[1] Reproduced from the Trans. Roy. Soc. Edin., 1882, vol. xxx., pl. viii., fig. 6b.
[2] Loc. cit., fig 6.
[3] Loc. cit., fig. 6c.
[4] Loc. cit., fig. 6a.

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one side. The extremely shortened tail is also well displayed, and the component parts of the tail fan. The telson is so wide compared with its length that there is no appearance of a constriction, but nevertheless it ends with a fimbriated band which doubtless represents the terminal fimbriated lobe in the more elongated forms.

Locality.—Chattlehope, Rede Water, Northumberland.

Horizon.—Calciferous Sandstone Series.

Collector.—J. Rhodes.

PSEUDO-GALATHEA ORNATISSIMA B. N. Peach. Pl. III., figs. 25–29.

1882. *Anthrapalæmon ornatissimus* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., pt. i., p. 83, pl. viii., fig. 7.

1883. *Pseudo-Galathea ornatissima*, B. N. Peach, Ibid., pt. ii., p. 515, pl. xxviii., figs. 7–7b.

Remarks.—Additional information has been obtained with regard to this species. Figs. 25, 26, natural size, show the relation of the carapace to the tail. They also show the great contrast between the flagella of the antennæ and those of the antennules, the wide sternites showing up through the crushed carapace, the tail segments, and the tail fan. The tip of the telson in the present form appears to be bordered by a fimbriated band which is not divided off from the rest of the telson by a constriction, as in *Ps. macconochiei*. Figs. 25–27 show some of the details of the tail segments, and that the central ridge keel is continued through these as a ridge. In addition to showing the tail with its central ridge keel, fig. 25 exhibits the bases of several of the limbs on the left side and fragments of several others on the right side. In fig. 28 the tail fan of another specimen is shown enlarged two diameters. A restoration of this species drawn by me twenty years ago is shown in fig. 29.

Localities.—Glencartholm, Langholm, Dumfriesshire, and Coomsdon Burn, Rede Water, Northumberland.

Horizon.—Scorpion-bed and Cementstone Group (Tuedian), Scottish Calciferous Sandstone Series, and English Carboniferous Limestone.

Collectors.—A. Macconochie and J. Rhodes.

Genus ANTHRAPALÆMON J. W. Salter, 1861.

1861. *Anthrapalæmon* J. W. Salter, Quart. Journ. Geol. Soc., vol. xvii., p. 529.

Remarks.—It is proposed here to restrict this generic name to such applanated forms as the type species *Anthrapalæmon grossarti* J. W. Salter, having expanded

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carapaces, with the marked serrate median longitudinal keel interrupted only at the cervical fold and produced in front into the long rostrum, serrated lateral keels, and embossed areas of the carapace studded with short conical spines. The known species that would come under this genus are therefore :—

1. *Anthrapalæmon grossarti* Salter.
2. *A. dubius* (Prestwich).[1] [*Apus.*]
3. *A. russellianus* (Salter). [*Palæocarabus.*]

ANTHRAPALÆMON RUSSELLIANUS (J. W. Salter). Pl. IV., figs. 1–6.

1863. *Palæocarabus russellianus* J. W. Salter, Quart. Journ. Geol. Soc., vol. xix., p. 520, figs. 1, 2.
1867. *Anthrapalæmon russellianus* H. Woodward, Trans. Geol. Soc. Glas., vol. ii., p. 240, pl. iii., fig. 7.

Since Salter gave his description of this beautiful species in 1861 and again in 1863, a great deal of new material has been accumulating which enables organs and structures to be examined that were not preserved in the specimens available at that time. This is chiefly owing to the careful and discriminating collecting of Mr. R. Dunlop, who generously presented specimens of this form to the Geological Survey Collection. Under his guidance Mr. Tait has been enabled to add a further suite of specimens to the Survey Collection, so that with this material, aided by specimens kindly lent by Mr. Dunlop for the purpose, several points in the morphology of this species can now be cleared up which have a wide bearing upon the relationship, not only of the present species but of a whole group of kindred forms, to the recent Schizopod family Lophogastridae.

General Description.—The integuments are relatively thin, though firm and chitinous, the prevailing ornamentation being in the form of short, strong conical spines. The body is short and applanated, and the carapace is much wider than the general axis of the body. The general form of the creature is shown in fig. 6, drawn natural size, from a specimen belonging to Mr. R. Dunlop. The tail is somewhat displaced, the first two segments being driven in and hidden under the carapace, whereas during life a portion of the dorsal part of the last trunk segment would be visible when the animal was thus viewed from above. As a consequence of the

[1] *Apus dubius* Prestwich, (from Milne Edwards' note) in Trans. Geol. Soc., 2nd ser., vol. v., pl. 41, fig. 9, 1840.

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applanation the remains are seldom fossilised sideways, and, owing to the very prickly back and the prominent ridge keel which cause it to take a strong hold of the embedding sediments, the fossil often splits so as to show the ventral side. When the splitting takes place along the back, the tips of the spines and the crests of the keels remain embedded in the counterpart, and thus the test seems to be perforated by innumerable more or less nearly circular holes, and the serration of the crests is not apparent. The points of the spines on the carapace are all directed forward. This is most apparent in the serrations of the lateral keels, which are really only flattened spines. The spines found on the posterior segments of the tail and the tail fan are all directed backwards, showing that the animal kept its powerful tail in reserve for darting suddenly backwards, as in the recent Macrura. The carapace (fig. 1) T. 2763^{B}, as seen flattened, is subquadrate, a little longer than broad, with somewhat bulging sides. The anterior margin is slightly convex and is produced into a long pointed and serrated rostrum, while the posterior margin is slightly concave. The antero-lateral angles are each marked by a strong, forwardly-directed, flattened spine. The apparent lateral margins are serrated by a series of smaller spines back to the postero-lateral angles, the posterior margin here making nearly a right angle with the sides and being edged by a double smooth band, with a deep median groove somewhat like an ogee moulding. There is good reason to consider that what appears as the lateral margin in the fossils is not the true edge of the carapace, but merely a serrated, strongly-developed, short longitudinal keel, and that the true edge bordered by the usual plain band, folded inwards during the life of the animal, became crushed under the carapace on being embedded. An indication of this is shown in the specimen from which fig. 1 was taken, where part of the test is seen to pass inwards for a short distance from the posterior angles, and this is of common occurrence in the fossils. The infold of the carapace is even better shown in fig. 2, T. 2766^{B}, which is a view from beneath of a specimen preserved back down. On the left side of the animal (the right hand of the beholder) a pellicle of sediment is seen to be interposed between the broken limbs and the underside of the carapace. That it is the underside is shown by the spines which stud its back, showing as retreating funnel-shaped hollows; but there is a belt of test just within the serrated margin studded with smaller spines which stand out towards the observer showing that it is the outside aspect of the carapace. It is therefore highly probable that the doublure may account for the earlier figures of this form and of kindred species, showing the serrations along the anterior part of the lateral margins only. Fig. 4, T. 2753^{B}, taken from a specimen in the Geological Survey collection, illustrates this point and shows how this could easily happen. On the left side, the carapace

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is bounded by the serrated edge of the keel, while the doublure is folded inwards. On the right side, however, the serrated edge of the keel only forms the boundary of the anterior half, while the doublure makes up the other, the spines of the keel there being shown end on and with their tips broken off as usual. Another point is well illustrated in this specimen, viz., that many of the spines on the embossed part of the carapace are not broken, and are seen to be directed forwards. There is a well-marked V-shaped cervical fold passing inwards and backwards from near the base of the antero-lateral spines to the mid-line of the back a little more than one-third of the length of the carapace, measured from the base of the rostrum. The area in front of the fold is raised into a median elongated gastric mound which is surmounted by part of the sharp serrated ridge keel which is produced forward into the rostrum, but when traced backwards, dies down ere the cervical fold is reached. The rostrum is further strengthened by serrated lateral keels one on each side. Rows of strong spines arise out of the grooves produced by the keels of the rostrum. On each side of the central or gastric mound there is a depression with two dimples on its floor, beyond which there arise mounds on each side surmounted by short serrated keels set obliquely, so that if produced they would meet near the tip of the rostrum. They die down, on the one hand, ere reaching the marginal band, so that there is no supra-orbital spine, and on the other, in front of the cervical fold. The embossed areas in front of the fold are irregularly studded with longer and smaller conical spines bent forwards near their tips. The test along the floor of the cervical fold is almost free from spines except where it merges into the lateral border. The area behind the fold is divided along its whole length by a very sharp serrated ridge keel which merges behind into the thickened posterior margin. On each side of this keel there are highly embossed areas or panels extending to within a short distance of the serrated margins, where the test is thickly studded with larger and smaller short conical spines directed outwards and forwards. There is, therefore, a space near the serrated margins free from spines or with only very fine ones. The sides of the ridge keel are also free from spines. It may be, therefore, that the marginal bare space may represent the upper edge of a lateral keel. The serrated margin may thus be the homologue of one of the lateral longitudinal keels in *Gnathophausia* which often bears a flattened spine, the "branchiostegal" spine of G. O. Sars. If this be the case, then there is a doublure in those species of *Gnathophausia* in which the keel bearing this spine is developed, and such carapaces would fossilise similarly to those of our species.

The sternites of the last seven segments (fig. 2) T. 2766^{B}, form a wide sternum, narrow in front and increasing in breadth backwards, rapidly at first, and then more

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gradually. They are all more or less welded together; but the division lines are still very distinct and the test at these parts appears to be folded well inwards to give lateral rigidity, and there is an arching of each segment so as to produce a sort of interrupted blunt median crest. The arrangement is almost identical with what takes place in *Pygocephalus cooperi*, as described by Huxley,[1] and which is so characteristic of this group of Schizopods (pl. iv., figs. 8, 9)[2]. That these sternites were only imperfectly soldered together is shown by some of them being displaced. This specimen (fig. 2) also helps to show that the carapace was quite free from these segments and only loosely covered them, for the long axis of the sternum does not agree in direction with that of the carapace. Another point is illustrated by this specimen, and by fig. 3, viz., that the carapace must have extended laterally far beyond the body walls of these segments.

The tail is flattened and shorter than the carapace, and the first segment appears to have almost touched the carapace in the mid-line of the back, as shown in fig. 3, so that only a very slight part of the last trunk segment could be exposed. The first tail segment is nearly as wide as the posterior part of the carapace, and the epimera seem to have been small. Part of the second tail segment is also shown in this figure, and reveals the width of its sternite between the bases of the pleopods. In this specimen the other segments are shown edgeways, so that the natural arch of the back and the epimera are thus probably indicated. The dorsal aspect of the last four tail segments is shown in fig. 5, as well as the telson and the left pair of uropods. The segments are all much alike, very wide compared with their length, with wide-apart pivots and well facetted anterior margins for rolling, with a smooth area in front and an embossed band behind set with backwardly-directed flattened spines, and with widely spread, sharp, triangular-shaped epimera. Each segment has also a narrow smooth band along its posterior margin. There are also two rows of short transverse keyhole-like slits bordered by a smooth flattened edging, two placed on each segment in advance of the pivots, and also upon the telson behind, the rows gently converging backwards as if the general axis of the tail were also narrowing in that direction, although this is barely apparent to judge by the epimera. There is a trace of a median ridge or longitudinal keel upon all the four segments, which reappears in the telson and its terminal lobe. The telson is triangular or leaf-shaped, with its broad base articulated with the sixth segment. Its sides are produced into denticulated lobes, and it terminates in a central heart-shaped lobule which appears as if it were articulated with it. The telson is ornamented with a

[1] Quart. Journ. Geol. Soc., 1857, vol. xiii., p. 363, pl. xiii., figs. 1–3.

[2] Reproduced from Huxley's original figures for comparison.

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similar sculpture to that found on the embossed portions of the tergites of the tail segments, and also with the transverse slits. It appears to have supported accessory swimmerets articulated with it near the base of the terminal lobule.

The eyes are very large, and were evidently placed on very short stalks (figs. 2, 3, 6), but they are too much crushed to show whether there was any ocular papilla. The antennules (figs. 3, 6) are supported upon large three-jointed peduncles which extend beyond the antennal scale, but not so far as the tip of the rostrum. The basal joints are elongated and hollowed out for the eyes to move freely, as in the recent Lophogastrids and Euphausiids with large eyes. The mid-joint is nearly quadrate in shape when flattened out, and not short and swollen as in *Gnathophausia*. It is ornamented with a longitudinal spinose ridge set obliquely inwards, is fringed on its inner margin with setæ, and terminates on its inner side in a spur. The terminal joint is a little longer than broad, bears a median ridge, and gives off two moderately long many-jointed lashes, the first joints of which are elongated and leaf-like. The external branch is the stouter and longer of the two; but there is not the marked difference between them that occurs in their modern congeners. The antenna (figs. 3, 6) is altogether more massive than in *Gnathophausia*. There is a short stout scale toothed on its outer margin, constructed as in the true caridea. It does not reach beyond the base of the lash. The basal joint of the peduncle has not been observed. The second joint is tumid and tuberculated, and the third joint is more elongated and the articulation between the two joints has great play. The terminal lash is very massive and longer than the carapace, and circular in section as shown on the right side of fig. 3, while that of the left side is evidently flattened through being crushed. The mandibles are very strongly developed and the body is tumid, but the details of the biting and molar portions are not easily made out (figs. 2, 3). The palp is three-jointed and pediform, as seen in fig. 3, the right one being attached to the body and the left one seen outside the left antero-lateral spine. The maxillæ are seen displaced in fig. 2, but not in a fit state for study. The biting edge of the first maxilla is the only structure that can be made out with any approach to certainty. Three of the flattened tumid joints of the endopodite of the maxillipedes are seen pressed on to the body of the mandible in fig. 2. This part of the limb seems to have been much as in *Gnathophausia*. The legs on the seven last trunk segments appear to be constructed and arranged on a similar plan to that in *Tealliocaris*. Six of the endopodites are seen in regular succession, not much displaced (fig. 3), all lying within the margin of the carapace. The specimen, fig. 3, which belongs to Mr R. Dunlop is fossilised partly in iron pyrites and shows a back presentation in which a large part of the carapace has split away with the counterpart, and so allows the limbs and many of the ventrally situated

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organs to be studied. The endopodites are all much laterally compressed and set along their edges with more or less regularly placed bristles and with tufts arranged in lines along their sides. As in *Tealliocaris*, the first of these legs is more massive than the succeeding ones. The legs become longer and larger in succession, the penultimate joint being the longest and the terminal joint spatulate and with no terminal claw. The backward flexing of the limb occurs at the articulation between the second and third joints from the tip. The actual basal joints have not been observed in this specimen. Fragments of the exopodites of five of these limbs are seen, and also that of the seventh limb. One of these, probably the fifth, shows the usual muscular basal joint and part of the many-jointed swimming lash, which is particularly strong. The others are represented by portions of the lash. These cannot be far out of place relatively to their respective endopodites, for the gills are found interposed between these two structures. A seventh leg is probably hidden under the portion of the carapace which has not been removed, for a lash and a gill are seen placed relatively to one another outside the fragment of carapace as if this were the case. The gills appear to be lobulated as in *Tealliocaris*. An exopodite, probably belonging to the right side, is seen projecting from the right postero-lateral angle of the carapace. Fragments of the seven endopodites and their corresponding exopodites are shown on the left side of the body in fig. 2 with a pellicle of shale separating them from the carapace. Six flattened quadrate-shaped plates intervene between these undoubted limbs and the wide sternal plates. The anterior margin of each plate overlaps on to the plate in front in turn, and the plates are arranged so as to appear to be placed opposite the interstices between the margins of the sternites. The plates, moreover, seem to be hollow or made up of two layers of the test, which is delicate and thin and much pitted. These are, in all probability, identical structures to those which Huxley in his figures of *Pygocephalus cooperi*[1] (figs. 8, 9) has interpreted as the coxal or basal joints of the limbs, but the mode of their occurrence in the present species is more suggestive of their being of the nature of epipodites like the plates found in the recent *Anaspides* described by Calman[2] (pl. viii., fig. 11). Although not described, there are small structures similarly placed in *Tealliocaris*.[3] Small epipodites furnished with sensory hairs are also found on the basal joints of the limbs in *Gnathophausia*.[4] Calman thinks that the plates in *Anaspides* function as gills, as they easily could in such

[1] Loc. cit., pl. xiii., figs. 1, 2, 3.

[2] Calman, Trans. Roy. Soc., Edin., 1897, vol. xxxviii., p. 787., pl. xxxviii., fig. 1.

[3] Pl. i., fig. 7a.

[4] G. O. Sars, "Report on the Schizopoda." Results of Voyage of H.M.S. Challenger 1873-1876., pl. viii., figs. 9, 10.

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a small form. Epipodites in *Gnathophausia* are set with sensory hairs, and appear to function as gill cleaners. The function of the present plates, whether they be the expanded basal joints of the legs or epipodites, appears to be protective to the gills, lobules and filaments of which are shown in the areas between the margins of the plates and the divisions between the sternites (fig. 2). The natural inference is that they may be breeding lamellæ[1]; but the two organs placed at the posterior margin of the seventh sternite suggest that the remains are those of a male.

Only the uropods of the sixth tail segment have been observed (fig. 5). They consist of a flattened, short triangular-shaped propodite, with the characteristic ornamentation and median crest. The exopodite is broad, flattened, and leaf-like. It is strengthened along its outer side in the usual manner, and appears to have supported a row of spines and bristles and to have terminated in the usual spine. The inner side is more web-like and set with setæ. There is the usual terminal lobe separated by the transverse suture, and this is fringed along its outer margin by setæ. The endopodite is also very broad, subquadrate, and leaf-like. Its outer margin is minutely serrated, and its posterior outer angle is a sharp point. Its posterior margin forms a sigmoid curve, and is fringed with setæ.

Locality.—Greengairs, 3½ miles N.N.E. from Airdrie, Lanarkshire.

Horizon.—Soft band ironstone. Lower Coal Measures, "Lanarkian."

Collectors.—R. Dunlop and D. Tait.

ANTHRAPALÆMON RUSSELLIANUS, var. SPINULOSUS var. nov. Pl. IV., fig. 7.

There appears to be a considerable amount of variation in the carapaces of this species, especially in the number and size of the spines with which the embossed portions are studded and also in the number of the serrations along the edge of the lateral keels.

General Description.—There is, however, a form which recurs that is altogether more delicately constructed and in which the proportions are somewhat different from the central species, and which may, when more is known of the animal to which it belongs, eventually entitle it to specific rank. Fig. 7, T. 2768[B], shows such a carapace flattened out in the manner in which the fossil is usually found. The rostrum is more slender than in the parent species, the anterior margin between the rostrum and the antero-lateral spine is wider, the spine itself is smaller, and the serrations on the edge

[1] This inference receives strong support from the description of breeding lamellæ upon *Pygocephalus cooperi* Huxley, by Dr. Henry Woodward, while this monograph was in slip proof. See Geol. Mag. Dec. v., vol. iv., 1907, pp. 400–407, pl. xviii., and text figures.

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of the lateral keel more numerous. The spines on the back of the carapace are also less in size and more thickly clustered. The test, too, is quite thin and much wrinkled, the wrinkles winding in and out round the bases of the spines. For this recurring form the varietal name is proposed to distinguish it from the more sturdy parent form with the more formidable spines.

Locality and horizon.—Same as above.

Collector.—D. Tait.

Remarks.—Before leaving the genus *Anthrapalæmon* it may be as well to consider, in the first case, the relationship of *A. russellianus* to the other species of the genus, and afterwards, of the genus to allied forms. To judge of *A. grossarti* Salter, as originally figured by him[1] and afterwards by Dr. Henry Woodward,[2] it bears a close resemblance to *A. russellianus*, having the same general short flattened form, especially of carapace, with the same serrated lateral keels and antero-lateral spines; but the serrated ridge keel extending into the long rostrum and interrupted at the cervical fold does not reach the posterior margin, and the fold does not seem to be so pronounced. In the tail, the six segments appear to be like those of the latter species, only there seems to be a difference in the nature and distribution of the ornamentation. The tip of the telson and of the uropods in *A. grossarti* are broken off, but to judge from the portions left the lateral margins of the telson are smooth, while those of *A. russellianus* are lobated and serrated. The general form and arrangement of the uropods is much alike in both. There is a strong general resemblance between the carapace of *A. russelianus* and that of *A. dubius* Prestwich [*Apus*]. There is a similar denticulated rostrum. The ridge keel, interrupted at the cervical fold, is continued back to the posterior margin, and there are embossed areas set with blunt spines. There are similar serrated marginal keels, but there is not the same pronounced spine at the antero-lateral angles in *A. dubius* as in *A. russellianus*.

To judge from the arrangement of the sternal plates and the limbs and tail fan of *Pygocephalus cooperi* Huxley (pl. iv., figs. 8, 9), as figured by him[3] and afterwards by Dr. H. Woodward,[4] there is a close relationship between that form and the members of the present genus. There is the same applanated and shortened form, with the body axis very much narrower than the carapace, as shown in all the figures, for there can be no doubt that Huxley was correct in his conjecture expressed in the last paragraph on

[1] Quart. Journ. Geol. Soc., 1861, vol. xvii., p. 531, figs. 1–4.

[2] Trans. Geol. Soc. Glasgow, 1867, vol. ii., p. 234, pl. iii., figs. 5–6.

[3] Quart. Journ. Geol. Soc., 1857, p. 369, pl. xiii., figs. 1–3.

[4] Trans. Geol. Soc. Glasgow, 1867, vol. ii., pl. iii., figs. 1–2.

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p. 367[1] of his description that "the narrow longitudinal plates are the edges of a short carapace" which shows a corresponding doublure, but is not serrated along its outer margin as it would be if it belonged to a member of the present genus. The tail, as shown by Woodward (pl. iv., fig. 10), is very much like those of *A. grossarti* and *A. russellianus*. The telson appears to have been constricted and to have expanded again near its tip, and its margin seems to have been denticulated and lobulated, and the uropods similarly broadened. The arch of the tail segments and the form of the epimera are all much as they are in *Anthrapalæmon*. There can be little doubt that the *Pygocephalus* of Huxley ought to take a place in the Schizopod family Lophogastridæ, and it shows how acute were the perceptions of Huxley that he compared his forms with the recent Mysids, as he was not then aquainted with the structure of the recent *Lophogaster*, which was only described in the previous year by M. Sars[2] and was for long after the only known member of the group. Since then, other genera have been discovered and described and are now ranged under the family of the Lophogastridæ, by G. O. Sars, the distinguished son of a distinguished father. *Pygocephalus huxleyi* H. Woodward, at first placed under this genus by Huxley[3] and afterwards described under the specific name by Dr Henry Woodward,[4] who, however, was doubtful of its generic relationship, if one can judge from the figures, is manifestly not a Lophogastrid, but belongs to the Schizopod family of the Euphausiidæ, and, as will appear in the sequel, is probably a species of the genus *Crangopsis* [*Palæocrangon*] of J. W. Salter (pl. xi., fig. 8). The tail of a form, however, probably nearly allied to *Pygocephalus cooperi*, was described by Dr. Henry Woodward under the name of *Necroscilla wilsoni*,[5] who considered that it had affinities with the Squillids. The specimen figured represents the last five tail segments and the tail fan enlarged 3 diameters. There is the same flattened, though perhaps slightly more elongated form, as in *Pygocephalus*, the telson is serrated or lobulated and carries two heart-shaped plates articulated with it in the position usually taken up by the accessory swimmerets that were so common in these Carboniferous Lophogastrids. The test is smooth as in *Pygocephalus*. The specimen is from the Coal Measures of Derbyshire. It is perhaps a coincidence; but it may be of zonal value, viz., that all the specimens of *Anthrapalæmon*, as now restricted, and *Pygocephalus*, are from the Coal Measures, the only shortened flattened form known from the Lower Carboniferous strata being *Pseudo-*

[1] Quart. Journ. Geol. Soc., 1857.

[2] Forhand. Skand. Naturf., Mode i., Christiania, 1856, p. 160.

[3] Quart. Journ. Geol. Soc., 1862, vol. xviii., p. 421 (woodcut).

[4] Trans. Geol. Soc. Glasgow, 1867, vol. ii., pp. 243–245, pl. iii., fig. 3 and woodcuts 1 and 2.

[5] Quart. Journ. Geol. Soc., 1879, vol. xxxv., p. 549, pl. xxvi., fig. 3.

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Galathea. It might be argued that the Coal Measures form inhabited fresh water, while the Lower Carboniferous forms were marine; but the fact that *Anthrapalæmon grossarti* is found associated with such marine forms as *Lingula* and *Conularia* has been long known.[1]

Family PERIMECTURIDÆ.

Remarks.—This family is made to include the members of a group of Mysidian Schizopods, believed to be intermediate between the Lophogastridæ and the Anaspidæ, conspicuous on account of the massive character of their tails in which they simulate the modern Squillids.

Genus PERIMECTURUS gen. nov.

Generic Characters.—Large forms with elongated and slightly applanated bodies; integuments firm and smooth, or only slightly granulated. Trunk shorter than tail; last seven trunk segments free, or only slightly attached, forming complete rings and bearing massive limbs; and in the females brood pouches on the hindmost segment. Carapace with movable rostrum and with or without longitudinal keels, not directly attached to last seven trunk segments, but covering them loosely and leaving visible portions of the last two in the emargination of its posterior border. Tail very largely developed; segments well formed with overlapping epimera, well facetted for rolling, and usually strengthened with transverse bars and often with longitudinal keel and spines. Telson cordate and ending in strong hastate median spine. External branch of uropods greatly developed and strengthened on outer side by blade-like keel set along its outer edge with a row of articulated spines.

Remarks.—The characteristic feature of the genus is the enormous development of the tail. The flattened body of the relatively shorter and broader species usually causes their members to be fossilised so as to expose the dorsal parts only, so that the sterna and ventral organs are usually hidden, as the integuments are too firm to allow them to show through. Fortunately, however, these animals shared, with *Mysis* (pl. vi., fig. 8) and other recent and palæozoic Schizopods, in the habit, on dying, of flexing the body at the articulation in front of the last seven trunk segments till the axis of the head organs and the carapace made a considerable angle with that of the trunk segments (pl. vi, figs. 2, 4, 5). At the same time, the limbs are all folded forwards close under the trunk, the distal joints of the legs being flexed back

[1] J. W. Salter, Quart. Journ. Geol. Soc., 1861, vol. xvii., p. 530.

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tight upon the middle joints. The tail is at the same time gently flexed, so that in spite of the applanation the dead animal comes to rest on its side and the fossil ones become thus embedded, and it is in this position that the more elongated of the fossil forms are found. The arrangement for the overlapping of the epimera is so complete that the curves formed by their edges, when the tail is thus flexed, remind one of those made by the adjustable iris diaphragm of some optical instruments.

To such large forms some special breathing organs would be a necessity, and from certain indications, seen in some of the forms, they appear to have been podobranchiate like their congeners the Lophogastrids and Anaspidians. The females appear to have borne brood pouches on the last trunk segment.

All the remains belonging to this genus have been found associated with those of marine or rather estuarine forms of animal life, mingled with land plants and with such air-breathers as scorpions and gally worms, showing conclusively that they were not deep-water forms.

PERIMECTURUS PARKI (B. N. Peach). Pl. V., figs. 1–5.

1882. *Anthrapalæmon parki* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx, p. 78, pl. ix., figs. 4–4g.

General Remarks.—This species was originally described by me under the belief that it was the remains of a macrurous Decopod, a position no longer tenable. Viewed in the light obtained from the study of the recent Lophogastridæ and *Anaspides*, which was not then possible, and from the study of the well preserved remains of *Tealliocaris* and *Anthrapalæmon* afforded by the present Survey collection, it can no longer remain in the genus *Anthrapalæmon*, nor can it be looked upon as a Lophogastrid, but must take its place beside the other well marked species of the present genus. A considerable amount of new material is now available, making it necessary that some additions to the original descriptions should be here given. Fig. 1 shows one of the largest specimens yet obtained, natural size, which is over 150 mm., or about 6 inches long. The massive tail characteristic of the genus, with the almost parallel sides equally so of the species, are well seen, as well as the details of the tail fan. The new features afforded by the present specimen are that the last five or six trunk segments are complete rings with closed-in dorsal parts, and that they are free and only loosely attached, so that the word "Endophragmal" system, used in the orignal description of the species, is quite a misnomer. The size and form of this tail, with its pecular telson, uropods, and the free trunk segments, are strongly suggestive of affinities with the Squillids (pl. vii.,

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fig. 6), but this undoubted likeness is only seeming, and no more indicates close relationship than does the likeness of *Anthrapalæmon* to *Galathea*. It more probably points to the two forms having to assume a certain shape to suit similar conditions of environment. The specimen also shows that this form was supplied with forwardly-directed massive legs with one of the joints much longer than the rest and bent upwards or forwards. These are too much crowded together and too imperfect for their exact character to be made out; but they are sufficient to show that they are similar to the limbs found in other species of the genus. Fig. 2, also natural size, shows, better than has yet been seen, the details of the tail fan of a still larger individual than that just described. Fig. 5, natural size, shows better than in the former specimen the nature of the long joint of the leg with a short joint interposed between it and part of another where the limb flexes sharply and folds upon itself as in the recent *Anaspides* and other species of this genus. It also shows the movable leaf-like rostrum, the longitudinal keels on the carapace, and the suggestion of a backwardly-directed spine in the mid-line of its posterior margin. This point, however, was well shown in the original figured specimen. In the original description it was left doubtful as to there being an antennal scale. Fig. 3, also natural size, shows not only the movable rostrum, the stalked eyes, the antennule; but sets to rest this doubt, as it shows a short, broad leaf-shaped pointed scale furnished with an external spine. Fig. 6 is from a well-preserved specimen not wholly flattened. This shows a point that was missed in the original description, or rather shows that a misstatement was then made, viz., "that none of the ridge keels are continued on to it," referring to the area of the carapace in front of the cervical fold. Traces of two short remains of lateral keels occur in the area in front of the fold in places where they are usually found in *Anthrapalæmon* and *Tealliocaris*, and which often end in the orbital spine. This small but well-preserved individual helps to show how variable the form is in the present species, the carapace here being broader than long, and the tail is also remarkably broad for its length, especially when compared with fig. 1. This feature of variability of proportion is well exemplified in the figures which accompanied the original description.[1]

PERIMECTURUS PARKI, var. DUPLICICARINATUS var. nov. Pl. V., fig. 6.

General Description.—Figure 6 is drawn natural size from a specimen preserved in an ironstone nodule which has evidently formed not long after the embedding of the remains, and has thus prevented them from being crushed and

[1] Trans. Roy. Soc. Edin., 1882, vol. xxx., pl. ix.

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flattened like those found in shale. The specimen shows that the animal, as might have been expected, was naturally applanated, for it is nearly always found back up. This specimen also helps to show not only the variation in the proportions of the individuals that have been included in the species, as the individual is very broad for its length, but also that it is accompanied in this case by a duplication of the median longitudinal keel upon the tail segments. This seems to have come about rather by the suppression of the central ridge keel and the accentuation of two lines of the small buttresses that supplanted the transverse band behind the rolling facet which strengthens the anterior part of each of the tergites. In this specimen the lateral keels are continued down the tail as two lines of backwardly-directed spines. Another part shown in this figure is the peak in the mid-line of the posterior margin of the carapace suggestive of a rudimentary spine in continuation of the ridge keel. All these points are strongly suggestive of affinities with *Tealliocaris* and *Gnathophausia*. Fig. 4d, of the original description of the species, has also the double ridge[1] on the tail, but its proportions are much more slender than the form shown in fig. 6, although it was a larger individual.

Locality.—All the specimens of this species have been obtained from the celebrated scorpion bed, exposed in the River Esk at Glencartholm, near Langholm, Dumfriesshire.

Horizon.—The exact horizon of this bed is above the "Fell Sandstones," which are supposed to be represented in the Forth basin by the Granton and Craigleith Sandstones. The scorpion bed, according to this correlation, would therefore be somewhere about the horizon of the Wardie Shales, near the base of the Oil-shale bearing Group of the Calciferous Sandstone Series of Scotland.

Collectors.—Mr. A. Macconochie, and a few by the late Mr. T. Stock.

PERIMECTURUS STOCKI sp. nov. Pl. VI., fig. 1.

Specific Characters.—Large form with longitudinally keeled tail tapering gently to source of the uropods. Outer branch of uropods with enormously developed blade-like external keeled part extending beyond the tip of the telson, and furnished with a row of articulated spines on outer margin.

General Description.—The integument is thin, smooth and shining, and not much calcified, though evidently strong. Only a portion of the trunk is preserved, so that the eyes, the antennular and antennary systems are unknown. The carapace is also fragmentary, none of its borders have been preserved, and there is no means of telling

[1] Trans. Roy. Soc. Edin., 1882, vol. xxx., pl. ix., fig. 4d.

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whether it was supplied with longitudinal keels. There is a depression in the place where the cervical fold ought to occur, judging by the position of the depression caused by the crushing in of the body of the mandible. At least four of the last trunk segments are visible. The sternites of these are strong and wide, with central raised triangular area with wide base resting on anterior margin, as in *Tealliocaris* and *Anthrapalæmon*, the divisions between the segments being well marked and bordered by thickened margins. From these segments the limbs, the bases of which must have been wide apart, are all torn off. A confused mass of organs all squeezed up together is seen in front of the first visible sternite; among this, four joints of a very massive limb can be traced. The tip joint is spatulated, pointed, and short, and has a strengthening keel. This is succeeded by a short joint at the two articulations of which the limb is flexed back upon itself. The third joint from the tip is longer than the other two combined, and is laterally flattened and strengthened by longitudinal keels and gently curved upwards; this long joint is articulated to another joint, making an elbow with it and flexing forwards upon it. A portion of this last joint only is shown. This limb appears to be lying upon another and exactly similar one. As already stated, the position of the body of the mandible is indicated by the crushing in of the carapace. To judge from the position of the mandible, the limbs described and the mass of debris of other limbs and trunk organs seen, must be displaced and lying free from their original attachments. The tail is massive and long and tapers gently towards the sixth caudal segment. The individual segments increase slightly in length in turn, the sixth being somewhat the longest. Lateral longitudinal keels appear upon several of the segments, and it is natural to infer that there was a median keel upon these segments also, although the mid-line of the back is concealed. All the segments are supplied with well formed subquadrate epimeral lappets rounded in front and pointed behind, with strong strengthening bands along their anterior and lower margins, ending in a spine near the posterior angles. The epimera of the sixth segment are shorter and smaller than the others. The sternites of the tail segments are very massive and strong. The anterior strengthening band of each passes straight across from side to side, but the posterior margin is deeply hollowed out to allow for rolling. The triangular areas thus formed are perforated with very large pear-shaped hollows for the articulation of the bases of the pleopods, which must have been very massive and powerful. The sternite of the sixth segment seems to have been wide and smooth and with two tumid areas behind the lateral angles. It is evident that the bases of the epimera on this segment were not confluent as in *Gnathophausia*.

The telson seen from beneath is cordate and ends in the usual hastate spine. At

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the base of the spine there is articulated with the telson a spinous process which is evidently the keel of an accessory swimmeret. The cordate portion of the telson appears to have had a depression down the centre flanked by two tumid sides. Unfortunately the crack already mentioned traveres it along the mid-line, so that the position of the anal opening is not known. The uropods have a very short basal joint. The external branch shows the enormously developed blade-like portion extending far beyond the tip of the telson, the outer edge showing the articulations for the row of spines, and the portion of the web usually wanting in the corresponding portions of *P. parki* filled in. The internal branch is only represented by portions of the median strengthening keel, insignificant as compared with the outer branch, and which doubtless supported a fringed web.

Remarks.—Only one specimen is known of this handsome form, the portion of which preserved measures nearly 100 mm. (about 4 inches), and when complete the creature was manifestly still larger. Owing to its length and to its body being slightly curved at death, as already explained, the anterior part of its body is fossilised sideways, exhibiting the folded massive limbs, but owing to the enormous widely expanded uropods, the tail fan is exposed with the underside upwards, the intermediate segments adjusting themselves to allow of this twist. This is mainly brought about in the free trunk segments, as the tail segments seem to be too completely locked by their articular facets and pivots and by the overlapping of the epimera to allow of much lateral play. Unfortunately a crack runs obliquely through the specimen from the telson to the region of the middle of the back of the trunk, and along this line some of the test has broken away.

The present species is distinguished from *P. parki* by the tapering tail and the enormous external branches of the uropods.

The species is named after the late Mr. Thomas Stock, the finder, who at one time was secretary to the Edinburgh Geological Society.

Locality.—Wardie shore, Granton, Midlothian.

Horizon.—Wardie Shales, (Scottish) Calciferous Sandstone Series.

Collector.—T. Stock.

PERIMECTURUS ELEGANS sp. nov. Pl. VI., figs. 2–6.

Specific Characters.—Small elongate forms measuring from 50–70 mm. Integuments thin and smooth. Carapace longer than broad and faintly keeled in anterior part of mid-line and behind the cervical fold with the dorso-lateral and lateral keels.

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Movable rostrum with wide base becoming suddenly constricted and ending in a keeled bayonet-shaped bent down point; posterior margin deeply concave. Tail long and tapering, with traces of median and lateral keels in the form of a backwardly-directed spine which increases in length of base on each succeeding segment. Telson narrow and shield-shaped, with prominent central keel and long hastate median spine. Uropods as in *P. stocki*, but external branch not so long proportionately. Members differ slightly in proportions.

General Description.—As will be seen at a glance from the figures given of this species, it had the habit of preparing for interment as already described, so that it almost invariably gives a side presentment with the carapace and head organs bent over so as to expose the tergites of the trunk segment. In fig. 4, where the carapace is tilted rather further than usual, all the seven last trunk segments are seen. These decrease in size from behind forwards. The carapace is usually shown doubled together, and is seen to be a little more elongated and more deeply cut out at the back than in the type species. A trace of the median keel is seen in some specimens (fig. 5) in front of the cervical fold, but there is no means of knowing whether it appeared in the area behind. The lateral and dorso-lateral keels are faintly indicated in fig. 2. Figs. 2, 3, and 5 show the rostrum. In the case of fig. 3 it is bent relatively to the long axis of the carapace, showing it to be moveable, and in fig. 2 it is seen to be actually out of place. Two small knobs are often seen, one at each of the angles of the base, and the rostrum is bent down towards the tip. The tail is constructed as in the type species, but the last four segments show three rows of spines corresponding to the median and lateral keels. A trace of the median one is shown in fig. 2 on the second tail segment as a protuberance near the posterior margin. It is more pronounced on the succeeding segment, becoming a veritable keel on the fifth or sixth segments. The lateral keel spines do not reach so far back as the median ones. The segments are all supplied with the usual large epimeral lappets, which are directed downwards and are almost square, with rounded angles in front and pointed behind. The lappets are each bounded on their anterior and inferior margins by a thickened band, terminating in a spine, the spine ending in front of the posterior angle and nearer to it in each succeeding segment. The epimera overlap each other from before backwards, and even when the tail is extended to the full are not quite free from each other, thus adding greatly to the strength of the tail and forming a complete protection to the pleopods. So much so is this the case that the pleopods are seldom visible. The telson is acutely heart-shaped, or rather shield-shaped, and narrow compared with other species, and ends in a spear-shaped spine which is in direct continuation

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of the median keel. The other keels form the raised sides and end at the sudden constriction at the base of the median spine. Articulated to this constricted posterior part (fig. 6) are seen two spines, one on each side, which are doubtless the keels of accessory swimmerets.

The eyes have not been with certainty observed owing to the peculiar mode of fossilization already described, causing the front of the carapace to be hidden among the doubled up limbs. A suggestion of their presence is shown in fig. 5 and also in fig. 2^A, which is an enlarged drawing in outline of some of the structures seen in specimens, of which fig. 2 is natural size. The last two joints of the peduncles of each of the antennules are also shown somewhat displaced. The terminal joints in each case bear the usual two lashes, the external one being somewhat the larger and longer, though they are both small compared with the lashes of the antennæ. The position of the body of the mandible is almost invariably shown by a collapsed area near the antero-lateral border of the carapace, showing that the head organs are in direct connection with the carapace. In fig. 2^A a three-jointed limb-like organ is seen to pass forwards from the collapsed body of the mandible, but it appears to be too massive to be the palp of that organ. It is more probably three joints of one of the more anterior of the legs, or possibly the maxillepede. The same enlarged figure shows the nature of some of the endopodites of the appendages of some of the last seven trunk segments, which are very massive and laterally compressed. The tip joints are spatulated; the succeeding joint is short and subquadrate; the third joint is long and bent upwards and strengthened by longitudinal lateral keels. The articulations of these joints flex backwards. Succeeding the long thin joint there is a fourth which is short and subquadrate; the articulation between the third and fourth joints flexes forwards. The limbs cannot be traced any further inwards with certainty. The long so-called thin joint in all probability corresponds with the ischiopodite, in which case this limb would flex in the same manner as in *Anaspides* (pl. viii., fig. 11). Short fragments of many-jointed exopodites are to be made out among the broken-up debris of limbs. What appear to be gill filaments can also be seen at the junction of the sternites with the tergal portions of some of the trunk segments, and an organ lying detached is highly suggestive of a brood pouch. Fig. 4 shows what appear to be the basal joints of six of the exopodites on one side, still attached to their respective segments, and a seventh that has broken away. The endopodites are all flexed in the usual way and crowded and crushed upon each other. Figs. 2^A and 5 show what are probably the eyes in place, the crushed mandibles, and the folded legs, flexed in the usual manner and crushed up together. Of the tail appendages, only the uropods have been observed. These are very much as in *P. stocki*, only the basal joint appears to be proportionately

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longer and the exterior branch relatively shorter and narrower. The internal branch is represented by its central keel only, which is narrow and short. Fig. 6 shows the tail fan spread. In Fig. 6 the telson is wanting, and the two external branches of the uropods are pressed against one another.

Remarks.—The only form that this species could be confounded with is *P. stocki*; but it is easily distinguished from that species by smaller size and relatively more slender proportions, and the more elongated form of telson and relatively shorter uropods. The disposition of the spines and keels on the tail sufficiently marks it off from the other species.

Locality.—River Esk, Glencartholm, near Langholm, Dumfriesshire.

Horizon.—Scorpion bed, (Scottish) Calciferous Sandstone Series.

Collector.—A. Macconochie.

PERIMECTURUS COMMUNIS sp. nov. Pl. VII., figs. 1–5.

Specific Characters.—Body elongated, 70–100 mm. (3–4 ins.); slightly applanated; carapace longer than broad and without keels behind the cervical fold which crosses the back about halfway between anterior and posterior margins. Tail long, massive, tapering, and without keels, but with small median spines near posterior margins of last two segments. External branch of uropods only a little longer than the hastate telson.

General Description.—This handsome form has the habit of arranging for its obsequies common to the members of the genus, so that, being elongated and not much applanated, it is usually seen in side view and with the carapace tilted up and doubled together. As shown in fig. 4, natural size, the trunk makes up about one-third of the length, the other two-thirds being formed by the massive elongated tail. This is one of the very few specimens in which the carapace is in its natural position, and, looked upon sideways and slightly from above, the body is seen to be fusiform and fish-like, attaining its greatest breadth and depth at about the second or third tail segment and tapering more backwards than forwards. The carapace is of the usual subquadrate form, a little longer than broad, with rounded posterior angles and emarginate posterior border. Its only ornament is the thickened margin. The cervical fold divides it into two nearly equal areas. No longitudinal keels have been observed behind the fold, and it is doubtful whether the fold of test that is found in front of it on the crest of the gastric portion represents a keel or is only an accidental wrinkle of the test. The rostrum is either divided off by a suture or is articulated with the carapace. It is broad at the base, suddenly narrowing, and continued as a blade-shaped downward-curved spine. Two

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keels having their origin in two knobs pass forward from near the base line convergently to the tip. The seven last trunk segments form complete rings as in the other species, and are either loose or only imperfectly fused together, their lines of demarcation being perfectly distinct. In fig. 5, where the carapace is tilted up in the manner already described, and especially where, in addition, it is partially removed as in fig. 1, these are seen to decrease rapidly in size when followed forwards from the hindmost one, which can be seen from fig. 4 to have been usually left bare or only covered by the posterior lappets of the carapace.

The tail is seen to be massive and muscular, with each segment well facetted for rolling, and supplied with the usual large subquadrate epimera with rounded anterior angles, almost straight external margins and pointed posterior angles, each fitting on to and overlapping its successor in the most perfect manner, reminding one very forcibly of the similarly formed tail segments of the recent Squillid, *Gonodactylus chiragra* Latreille, a drawing of which, natural size, for comparison, is shown in pl. vii., fig. 6. A small spine is seen on the mid-line near the posterior margin on the last two tail segments in fig. 1 and on the last tail segment in fig. 5. These seem to be representative of the median keel seen in *P. parki* and other forms. The sternites belonging to these six segments are seen in fig. 3, natural size, to be very strongly constructed, with the usual straight articulation in front in the first five segments and deeply emarginate posteriorly, and perforated with large pear-shaped articulations for the attachment of the basal joints of the pleopods. pl. vii., fig. 7, also natural size, is the tail of *Gonodactylus chiragra* drawn in the same position for comparison. In the sixth segment the articulations for the uropods are carried backwards and outwards to the posterior angles, so that the sternite forms a floor across the greater part of the underside within the epimera. The telson, best preserved in figs. 3–5, is seen to be shield-shaped and elongated, with median crest and long hastate spine behind the articulations of the accessory swimmerets. The outer edge of the telson was evidently set with a row of setæ or short spines, as the articulations for them have been observed in specimens from which fig. 5 is taken. The telson was supplied with articulated spines at the constrictions, which are evidently the keels of swimmerets.

The eyes are stalked and moderately large, and were in life probably partially covered by the expanded portion of the rostrum (figs. 1–4). The peduncle of the antennules is short, and does not reach to the tip of the rostrum (fig. 4). The antennual scale is short, leaf-like, and pointed (fig. 4) as in *P. parki*, and the flagellum more massive and longer than either of those of the antennules. The large body of the mandible is shown as usual by the collapse of the overlying carapace, but the palp has

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never been recognised owing to the habit so often referred to, and for the same reason the maxillæ and maxillipedes have not been recognised. The endopodites of the legs are all thrown forward and huddled together. The details of each appear to be much as in the other species, for the long upwardly-curved massive joint is conspicuous in all the specimens. In fig. 1 a fifth joint from the tip is seen in addition to the other four observed. This shows that the fourth is short, and that at the articulation with the fifth the limb flexes forward. Figs. 1, 2, and 5 all show a row of short joints, in which the test is not as dense as in the legs, which are directed downwards and slightly backwards, and which overlap the shorter proximal joints of the legs. They strongly suggest that they are the basal joints of the exopodites, and in fig. 5 there are structures folded upwards and forwards suggestive of their terminal swimming lashes. In fig. 1 the bases of these joints are obscured by fimbriated bunches which are strongly suggestive of gills.

The pleopods (figs. 1 and 2) have massive basal joints which extend beyond the edges of the epimera, and support leaf-shaped jointed swimmerets. There is no evidence to show whether the first two pairs of pleopods were modified in their inner branches for sexual purposes. Such evidence as the imperfectly preserved pleopods afford is rather against the presumption that anything like the tufts of filamentous gills that occur in the Squillids could be present without being observed; but the evidence either for or against it is not of much value. The uropods, constituted very much as in the two former species, are shorter relatively to the telson than in either of them. The basal joint is longer proportionately than in *P. stocki* and shorter than in *P. elegans*.

Locality.—River Esk, Glencartholm, near Langholm, Dumfriesshire.

Horizon.—Scorpion bed, (Scottish) Calciferous Sandstone Series.

Collectors.—A. Macconochie and T. Stock.

Perimecturus ensifer sp. nov. Pl. VII., figs. 8–14.

In the collection of the Scottish branch of the Geological Survey there are the remains of crustaceans belonging to this group which were obtained by Mr. Macconochie from the Cementstone group of the Calciferous Sandstone Series of Liddesdale, a somewhat lower horizon than the Eskdale scorpion bed. Some of these specimens were figured and described by Robert Etheridge, junior, in 1879,[1] and doubtfully referred to the Phyllocarid genus *Dithyrocaris*. The whole construction of the tail, with its epimera, telson, and uropods, shows that the form belongs to the present

[1] R. Etheridge, Jun., Quart. Journ. Geol. Soc., vol. xxxv., p. 464, pl. xxiii.

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group. This is now made certain by obtaining a specimen showing the carapace (fig. 8) and another, fig. 10, which shows the stalked eye, the antennules and antennæ, which, though now detached, evidently belong to the same individual as the tail. The specimens are much more fragmentary than those usually found in the scorpion bed, doubtless pointing to longer exposure before becoming embedded.

Specific Characters.—Moderately large forms with plain unkeeled carapace. Long, slightly tapering tails with median spine on last three segments. Telson long and narrow, with median longitudinal embossed sword-shaped area continuous with the hastate elongated spine. The external branch of the uropods about same length as telson.

General Description.—The carapace is of the usual form, but somewhat narrower anteriorly than posteriorly, and a little broader than long, without keels and with only the thickened border. There is a distinct cervical fold. The rostrum is leaf-shaped and probably movable. The sternites of the last trunk segment are wide; those in front become narrower and narrower in rotation. The last trunk segment is seen (fig. 9) to have parted from its fellow in front, and to be still attached to the tail, showing that it was either quite free or incompletely fused to the other trunk segments. The tail is elongated, but is not twice the length of the carapace. It has but slight taper, and is constructed on the usual lines of the members of the genus. The epimera are very strongly developed and are almost square. As usual, they are margined along their anterior and part of their inferior edges by the usual thickened band, ending in the backwardly-directed spine (fig. 12), and are well facetted for rolling. The last three segments have a backwardly-directed spine in the mid-line of the back near their posterior margin. On the fourth segment the spine is little more than suggested. On the fifth it is more pronounced, and on the sixth it becomes still more elongated. The under view of the tail is shown in fig. 8, where the creature is fossilised lying on its back. The square epimera are doubled down and partly conceal the sternites, which are seen to be strong and massive, and with their centre somewhat embossed or keeled and the triangular side portions pierced for the articulation of the pleopods. The fifth segment is slightly displaced. The sixth segment shows the track of the gut, which is evidently distended. The telson is, however, the organ which distinguishes this species. It is of the usual heart or shield shape, and constricted at about half its length for the articulation of the swimmerets, beyond which it is produced into the usual terminal spine; but in this species the spine is seen to be the extension beyond the body of the telson of an embossed median area like the xyphium of the old leaf-shaped cut and thrust sword, the manubrium being broken off. It is this likeness to a sword that has suggested the name.

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Localities.—Liddel Water, New Castleton, and Glencartholm, Langholm.
Horizon.—Cementstone group, Calciferous Sandstone Series.
Collector.—A. Macconochie.

PERIMECTURUS PATTONI sp. nov. Pl. VI., fig. 9.

1888. *Palæsquilla pattoni* Peach, Trans. Geol. Soc. Glasgow, vol. viii, p. 173. *Nomen nudum.*

Specific Characters.—Length of specimen, 35 mm. Integuments thin, smooth, and unornamented. Form moderately long, stout, and applanated, and with only slight taper of tail. Trunk measuring nearly one half of the length of the body. Epimera of tail segments comparatively small. Body of telson comparatively short.

General Description.—The integuments are so thin that the tail, except in the firmer parts, is much wrinkled. The trunk, which measures nearly half the length of the body, is seen to be curved upwards in the present specimen, carrying the carapace with it. This bend does not take place at the articulation in front of the last seven segments as in the other cases where the carapace and head organs are bent down; but four of the seven segments share in the bend. The carapace seems to have been of the usual form and without keels, but it is thin, and, being compressed against the underlying organs and having accidental wrinkles in addition, it is not easy to decipher. If it possessed a rostrum it was probably detached before fossilisation, or else it is folded down so as to be concealed; for although a portion of the carapace has been broken away, yet the position of the body of the mandible allows of the orientating of head parts sufficiently to show where they might be expected to be seen were they present and still attached. The last seven trunk segments form complete rings as in the other species, and the bend of the body already mentioned affords additional evidence of their being comparatively free. The last two of these show plainly that the lappets of the carapace overlapped their sides, only leaving the backs bare. The tail is particularly massive and with little taper, forming as usual the greater part of the body. The first six segments composing it increase slightly in length in backward succession. They are all provided with epimera, which appear to be less deep than those of the already described species, and of slightly different form, being more rounded off at the anterior angles and having hollowed out instead of straight inferior margins. They are strengthened along the anterior and inferior margins by the usual thickened band ending in a spine, but there does not seem to be the same complete overlap on to each other as in the other species, when the tail is fully extended as it is in the present case.

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There are no longitudinal keels, and there appear to be no spines even upon the hindmost segments; but this is difficult to say with certainty on account of the wrinkled character of the test. The telson, to judge from the part preserved, is of the usual type, but the cordate body of it appears to be shorter relatively to the terminal spine than in the other described species. The spine is continuous with a raised or embossed ridge on the body, and moderately large accessory flattened swimmerets are articulated with the body at the base of the spine.

Neither the eyes and antennules, nor the antennæ have been observed, as the specimen is evidently broken away where they might be expected to occur. The position of the body of the mandible is shown in the usual manner by the collapsed carapace. The maxillæ and the maxillipedes are unknown. The massive legs are folded up and huddled together, and closely pressed to the sternum as usual, thus following the upward bend of this part of the trunk. They are seen to flex at articulations corresponding with those in other species, the proximal joints flexing forwards and the distal ones in the opposite direction. The long joint is comparatively longer and straighter than in the other forms. What appears to be the tip of the exopodites is seen bending backwards and upwards from the elbow-joints of the folded-up endopodites. A point of the greatest morphological interest, however, is that, articulated with the sternites of the two last trunk segments, there are large bag-like structures identical in character with the marsupium of certain Mysid forms. In their compressed state they appear as leaf-shaped plates, each with narrow articulations, suddenly expanding beyond the articulation, with concave margin on one side and convex on the other, the two sides slightly converging and meeting in a rounded tip. A slit or invagination proceeding from about the mid-line of the plate, a little below the point of articulation, traverses the rest of the plate with nearly the same curve as the concave margin, but converging gently with it, and meets it near the beginning of the rounding of the tip. This slit does not expose the underlying shaly matrix, and is therefore either an invagination of the exposed side of the plate or else the plate is double, which probably is the case. A detached organ of similar character, but of somewhat more elongated form, is seen to occur among the *disjecta membra* of one of the specimens of *P. elegans* (fig. 2^A), and shown on figs. 2 and 2^A. There can remain little doubt, therefore, that these forms are correctly placed among the opossum-shrimps.

Remarks.—This specific name is given to associate this form with that of the late Mr. Andrew Patton, Manager of the Calderwood Cement Works, East Kilbride, Lanarkshire, to whom we are indebted for collecting not only this most interesting crustacean, but also other arthropods new to science.

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Locality.—Cementstone Quarry, East Kilbride, Lanarkshire.
Horizon.—Lower Limestones, (Scottish) Carboniferous Limestone Series.
Collector.—Mr. Andrew Patton.

Systematic Position of the Perimecturidæ.—Whatever may be the ultimate systematic position assigned to the forms included in this family as the result of future discoveries, there can be no doubt as to their forming a closely-connected natural group. The size and form of their tails and tail fans, coupled with the fact that many of the trunk segments are complete rings and comparatively free from each other, as well as being only loosely covered by the carapace or left bare, and also the movable leaf-shaped rostrum, naturally suggests affinities with the Squillids. These characters, however, are shared by the modern *Anaspides*, the Lophogastrids, and one may also add to these the Mysids. The occurrence of what are evidently breeding lamellæ or brood pouches in some of the species, the exopodites on the trunk legs, the wide sternites of the trunk segments, the mode of flexing the trunk limbs, and the habit of bending down the heads and carapace on dying, show conclusively that they are Schizopods. The correspondence in number and position of the longitudinal keels both on the carapace and the tail, in the present forms, with those on the modern *Gnathophausia* and *Tealliocaris* and other Palæozoic genera, as well as in the Mezozoic *Tropifer*,[1] appears to be more than a coincidence arising from similarity of environment, and more probably points to community of descent. It is unfortunate that the state of preservation does not allow of any definite knowledge of the nature and position of the special breathing organs that must have been a necessity to such large and muscular organisms. Such fragmentary evidence as is forthcoming is in favour of their having been developed from the free trunk segments, and that they were probably podobranchiate. Nothing resembling the gill tufts of the Squillids has been found near the bases of the pleopods. The view taken by the present writer is that, while they are well within the Schizopod sub-order, they may be looked on as having taken on Squillid characters, and may even have been the early progenitors of the Squillid stock.

Family ANASPIDÆ.

Remarks.—This family was erected by G. M. Thomson, of Dunedin, New Zealand, in 1894 to include the recent *Anaspides tasmaniæ* Thomson, still living in the

[1] Gould, Quart. Journ. Geol. Soc., 1857, vol. xiii., p. 360, figs. 1–3.

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mountain lakes of Tasmania.[1] It was subsequently more fully described by W. T. Calman,[2] who showed its affinities to the Palæozoic genera *Acanthotelson* Meek and Worthen, *Gampsonyx* Jordan and v. Meyer, and *Palæocaris* Meek and Worthen. The members of this family evidently belong to the great Mysid branch of the Schizopoda, but are evidently more nearly allied to the family of the Lophogastridæ than to that of the Mysidæ. Both the Anaspidæ and the Lophogastridæ seem to have branched off from the great Mysid stem together, but to have afterwards developed along different lines. One point of difference especially interesting to the describer of the fossil forms is that in the former family the carapace has not grown backwards so as to cover any of the last seven trunk segments (hence the present name), while in the latter it has done so, and in one genus, *Charalaspis*, it even overlaps well on to the tail segments, although in no case is it in direct fusion with any of them, but only covers them loosely. As Thomson's name is based on the study of the living animal, it is here adopted in preference to that of *Gampsonychidæ* of Packard, based upon the study of imperfectly preserved fossils. *Anaspides* must be looked upon as a surviving remnant of an old family in which many extinct forms were much more specialised than the survivor.

Genus PALÆOCARIS Meek and Worthen, 1868.

1868. *Palæocaris*. Proceed. Acad. Nat. Sc. Philadelphia, p. 48.

PALÆOCARIS SCOTICA B. N. Peach. Pl. VIII., figs. 1–5.

1882. *Palæocaris scoticus* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 85, pl. x., figs. 10–10h.

There are many specimens belonging to this species in the collection of the Scottish branch of the Geological Survey, besides those which furnished the material for the description of the species. In that description I expressed the opinion that it was to be looked upon as a lowly Schizopod, and a further study of the old material in the light of Sars' Report on the Challenger Schizopods still further confirmed me in that belief. Since then the living *Anaspides* was discovered, and its description by W. T. Calman[3] throws a flood of light upon the present genus and its allies, and makes the belief a certainty.

General Description.—The chief new structural points observed during the present

[1] Trans. Linn. Soc. Zool. (2), vol. vi., p. 3.

[2] Trans. Roy. Soc. Edin., 1896, vol. xxxviii., p. 787.

[3] W. T. Calman. Trans. Roy. Soc. Edin., 1896, vol. xxxviii., p. 787.

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study of the fossils are illustrated in fig. 4, which represents the trunk and tail segments of a very small specimen magnified about ten diameters. It shows plainly that the tail and trunk were well marked off from each other, and that there was more play at the articulation of the two than at any of those separating any other two segments of either trunk or tail. It also shows the well-marked epimera upon the tail segments and also the swollen pleura of the trunk segments similar to what takes place in *Anaspides*. Only six trunk segments are seen to intervene between the division and the posterior edge of the carapace. From the last one of these on the left side there projects the portion of a cylindrical limb showing three joints, and reminding one also of the endopodites of the living form. On the same side of the body, two segments in advance of that already mentioned, a structure is seen projecting beyond the segment which may be the joint of an endopodite; but it is even more like the basal joint of an exopodite without the terminal swimming lash. Some detached fragments of limbs are shown lying a little outside the postero-lateral edge of the carapace. One of these shows the last two joints of an endopodite constructed like those joints in the Lophogastrids.

Remarks.—Notwithstanding the fact that there are only six trunk segments uncovered by the carapace in this form, and that a seventh was shown to be partially covered by the carapace in a specimen described by me in the original paper before the Royal Society of Edinburgh, I still retain this form within the genus till further evidence is forthcoming. This remark applies equally to the following species.

Locality.—River Esk, Glencartholm, Langholm, Dumfriesshire.

Horizon.—(Scottish) Calciferous Sandstone Series.

Collector.—A. Macconochie.

PALÆOCARIS LANDSBOROUGHI sp. nov. Pl. VIII., figs. 8–10.

Specific Characters.—Comparatively large form. Carapace subquadrate, a little longer than broad, with rounded posterior angles and slightly hollowed out posterior margin; rostrum short and expanded at the base to form part of the eye-orbit; trunk and tail segments with median dorsal keel; sixth tail segment long and much constricted; telson subquadrate or slightly shield-shaped; uropods caridean in structure and only a little longer than the telson.

General Description.—Body 40–50 mm. long, flattened so that it fossilises back upward. The integument is thin and wrinkled.

As in *P. scotica*, the carapace only covers the front portion of the trunk, leaving six distinct segments bare. The carapace is subquadrate, a little longer than broad, and slightly narrower in front than behind. It is produced into a distinct though

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short rostrum which is expanded towards its base and hollowed out to form part of the eye orbit. There is a distinct gastric prominence passing inwards from the base of the rostrum, which is surmounted for a short distance by the crestal ridge of the rostrum. Two deep almost semicircular depressions pass in from the lateral line on each side, but do not meet in the mid-line. They may be the beginning of a cervical fold or they may represent the collapsed bodies of the mandibles. Near the posterior margin a transverse line crosses the carapace, which seems to indicate the presence of a distinct segment showing through, owing to compression.

The posterior angles of the carapace are rounded off and the posterior margin is slightly hollowed out. Behind the margin of the carapace six free trunk segments succeed each other. These are all constructed alike, as far as can be seen from above. They are all slightly tumid, with a central dorsal crest and a depression marking off the pleural portions from the tergites.

The tail consists of the usual six segments and the telson. The anterior segments are distinctly wider than those of the trunk; like them they are tumid and have a median dorsal keel, but they are supplied with distinct epimera, which are pointed and are directed backwards. The tail narrows at the fifth segment, and is much constricted about the middle of the sixth segment, which is appreciably longer than any of the other segments, and is crossed by a distinct sulcus at the constriction. The central ridge is continued through these segments. The telson is subquadrate, with nearly parallel or only gently converging sides. It is divided into two areas, a front tumid shield-shaped area and a posterior flattened area. The posterior margin of this flattened portion gives off a process in the mid-line, and the margin on each side of its base appears as if thickened for the articulation of accessory swimmerets.

The eye is large and stalked, and appears to have been partially covered by the expanded base of the rostrum. The antennules have a three-jointed peduncle surmounted by two flagella, the external one being the thicker and longer, but how much so is not evident, as the exterior branch is broken. The antenna has a broad basal scale, caridean in structure. The flagellum is more massive than the external flagellum of the antennules, and was probably much longer. As it bends off at right angles and skirts the anterior margin of the scale, it is presumed that the peduncle of the flagellum is the same length as the scale.

The appendages of the sixth tail segment only are exposed. They consist of the usual basal joint, which is moderately long and gives off the two usual plates. The exterior one with its strengthening keel was evidently traversed by the usual transverse suture, and the end lobe has been broken away; the internal branch, therefore, is seen to extend

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beyond it, and both were evidently extended beyond the telson when the tail fan was not spread out as it is on the specimen. Fig. 8 shows the only specimen known, natural size, which is not compressed. Fig. 9 shows the cast of the counterpart, and fig. 10 is an attempt to restore the parts exhibited in the fossil.

Remarks.—This species has been named after the Rev. David Landsborough, of Kilmarnock, a keen naturalist, who first brought the specimen to my notice.

Locality.—Kilmaurs, near Kilmarnock, Ayrshire.

Horizon.—Lower Coal Measures.

Family MYSIDÆ.

Remarks.—In the collection of the Geological Survey of Scotland there are very numerous specimens of the tails of higher Crustacea, about the systematic position of which there has been considerable difficulty, although the presumption was that they probably belonged to some members of the family Mysidæ. Last year, however, Mr. Tait, collecting under the guidance of Mr. Robert Dunlop, obtained from the Soft Band Ironstone of Airdrie specimens of tails like those about which there remained a doubt, and in which the auditory organ situated on the inner branch of the uropods is distinctly visible. On the strength of this evidence these tails are now with some degree of confidence assigned to the above family.

Genus PALÆMYSIS gen. nov.

Generic Characters—Integuments chitinous, thin, and smooth. Trunks unkown; tails long and fusiform, and segments supplied with well-developed epimera and well-developed pleopods. External branch of uropods much longer than the forked telson; internal branch of uropods short, so that the tail fan is deeply forked.

Remarks.—It is almost certain that the above characters are so general that it will yet be found, when better preserved material turns up, that our genus will include the species of several genera. It is, therefore, only proposed provisionally to bring together a group of tails in which there is a great similarity in form and construction.

PALÆMYSIS DUNLOPI sp. nov. Pl. VIII., figs. 12–14.

Specific Characters.—Tail fusiform, tapering from second segment; first five segments with well-marked obtusely-pointed epimera; sixth segment longer and narrower than the rest. Telson shorter than uropods, grooved down the middle line, forked, bearing accessory swimmerets at the two extremities, and set with a row of

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bristles along each external margin. External branch of uropods large and blade-like, and much longer than the internal branch, which is thin and delicate.

General Description.—The integuments are thin. The trunk is unknown.

The tail measures 25–30 mm., and is long and sub-cylindrical and fusiform, tapering backwards from the second segment, which is the largest, to the spring of the basal joints of the uropods on the sixth segment, which is nearly double the length of any of the others. The first five segments bear well-marked epimera, which are obtusely pointed, those of the first segment being considerably shorter than those of the succeeding one and overlapping on to it. Those of the other segments overlap each other in order backwards. There are distinct pivots at the bases of the epimera, and the segments are well supplied with smooth facets for rolling. The epimera of the sixth segment are small and only found on the anterior part.

The telson is much shorter than the external branch of the uropods. It is tumid at the base and flattened behind. A median groove commencing in the tumid portion is extended into the flattened termination, causing the tail to be distinctly forked. The two ridges left by this furrow are each traversed by a longitudinal groove, which has a gentle curve outwards and terminates on the exterior margin. The two raised areas are prolonged beyond these grooves and terminate abruptly, forming an articulation for two flattened plates which act as swimmerets. The lateral margins of the telson are set with an even row of strong bristles, and the flattened plates and the fork are fringed with setæ.

The appendages of the tail (figs. 12, 13) on the first five segments appear to be constructed with very strong muscular basal joints, and to have terminated in at least one branch constructed as a many-jointed swimmeret, but the terminal portions are not sufficiently well preserved to determine whether the inner branch of the anterior pleopods was modified for sexual purposes, or whether they bore the rudimentary gills like those of the males in some of the recent forms; but the general character of the remains preserved suggests that these pleopods were probably like those of the males in the recent *Siriella* and *Amblyops*. The uropods have a flattened subquadrate basal joint, the inner part of which is overlapped by the bulge of the telson when the tail fan is not spread. The external swimmeret is much elongated and blade-like, and tapers to a sharp point, having an elegant double curve, first outwards and then inwards as the tip is approached. It is strengthened exteriorly and traversed throughout the greater part of its length by a double fluting. Its inner edge is thin and fimbriated. It therefore bears a strong resemblence to an Eastern stabbing-knife. It was evidently set with strong setæ along its inner margin. There appears to have

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been no provision for articulated spines along its outer margin. The inner branch is much smaller and of more delicate construction. Near its base, which is slightly swollen, there is an oval ring within which there is a smooth saucer-like depression, in the centre of which there rises an inner, much smaller oval ring, or rather flat boss. As the structure has been found occupying this position in all the tails examined and on both sides of the telson, there is left no room for doubt as to its representing the auditory organ similarly situated in the tails of the recent Mysidæ. The portion of the uropod which projects beyond this organ is weak and thin, linguate in form, and set round with fine setæ, and does not extend beyond the end of the telson. The whole tail fan when expanded is deeply forked or swallow-tailed. The species is named after Mr. Robert Dunlop, to whom I feel deeply indebted for having placed his collection of tails at my disposal for study.

Locality.—Greengairs, 3½ miles N.N.E. from Airdrie, Lanarkshire.

Horizon.—Soft Band Ironstone, Lower Coal Measures, "Lanarkian."

Collectors.—R. Dunlop and D. Tait.

PALÆMYSIS COUTTSI sp. nov. Pl. VIII., figs. 16–19.

Specific Characters.—Only the last few tail segments known; sixth segment relatively longer and narrower than in *P. dunlopi*; telson relatively shorter and more deeply notched; the blade-like external branch of the uropods relatively longer than the internal one, so that the tail fan is deeply swallow-tailed when expanded.

General Description.—This name is proposed for a species which, to judge from the last segment and the attached tail fan shown natural size, is seen to be nearly allied to *P. dunlopi* just described. From that form it differs in its much greater size and more elongated and elegant proportions, especially of the last tail segment. The telson is relatively shorter and more deeply forked, and the external branch of the uropod, which is of the same blade-like character, is relatively much longer than the telson, and the inner branch is also longer than the telson. The auditory organs have not been observed, although they no doubt occur.

Remarks.—The specimens from which the drawings were made were submitted to me by the late Mr. Coutts of Glasgow. They are now in the Natural History Collection of the Royal Scottish Museum, Edinburgh. By the kind permission of Dr. Dobbie, the Director, I now make use of my drawings for this description.

Locality.—Cementstone Quarry, East Kilbride, Lanarkshire.

Horizon.—Lower Limestones, Scottish Carboniferous Limestone Series.

Collector.—And. Patton.

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PALÆMYSIS TENUIS sp. nov. Pl. VIII., figs. 20–24.

Specific Characters.—Smaller, more delicate form, with relatively less taper in tail and with less difference between the length of the uropods and the deeply-forked telson than in the type species *P. dunlopi.*

General Description.—This name is proposed for a small form the tails of which occur in great profusion in certain layers of the "Scorpion-bed" exposed in the River Esk, Glencartholm, near Langholm. The integuments are so thin and delicate that the fossils can only be seen when the slabs are held in a certain light, hence the name. Figures drawn natural size show the nature of these tails and the relative proportions of their parts; only in one case, fig. 23, has anything approaching what might be construed as a trunk organ been seen. In that figure, what is probably a very short carapace is seen doubled together, and the remains of what may have been one of the limbs. As can be seen, there is a difference in the proportion of some of the forms, some being much more slender than others, but this may only indicate sex. They all agree in having the sixth tail segment more elongated than the rest, in having a very short forked telson with a marked median line, whether ridge or depression is not certain, and terminating in accessory swimmerets. The external branch of the uropods is long and blade-shaped, and the inner branch short, weak, and linguate. Fig. 24 shows one of the specimens enlarged. Fig. 15 is drawn from a recent *Mysis* from Granton, for comparison.

Locality.—Glencartholm, Langholm, Dumfriesshire.

Horizon.—Calciferous Sandstone Series.

Collector.—A. Macconochie.

PALÆMYSIS sp. Pl. VIII., fig. 25.

Yet another portion of a tail evidently belonging to species of this group occurs in the collection made by Mr. Macconochie from the Langholm Scorpion-bed. It is shown in fig. 25, natural size.

Family EUPHAUSIIDÆ.

In the collection of the Geological Survey of Scotland there are a great many specimens of fossil Crustacea from the Carboniferous Rocks which must be placed within this family. In these forms all the legs are distinctly developed as in the modern genus *Bentheuphausia* of G. O. Sars.

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Genus ANTHRACOPHAUSIA gen. nov.

Generic Characters.—Elongated, laterally-compressed, prawn-like forms, with thin smooth chitinous integuments generally fossilising sideways. Carapace less than one-third the length of the body, loosely attached and leaving bases of limbs and tergites of last trunk segment bare, produced in front into a carinate rostrum, and with only slight trace of cervical fold; peduncle of antennules long and massive, with last two joints extending beyond the rostrum; antenna with basal scale and with flagellum longer than those of antennule. Seven pairs of legs all constructed alike and generally diminishing in size from before backwards. Tail segments with deep epimera all directed downwards and backwards; first two pairs of appendages of tail in the males very massive and specially modified for sexual purposes, one branch of the first pair being furnished with coupling hooks. Luminous globules present on trunk and tail. Telson nearly as long as the uropods, and furnished near its end with two articulated plates, one on each side.

Remarks.—The present genus is constructed to hold a set of fossil forms with a distinct falciform rostrum distinguishing the members from those of the already made genus *Crangopsis* [*Palæocrangon*] of Salter, in which the rostrum is either inconspicuous or entirely absent. In the best-preserved specimens of some of the species of the genus the small globular light-producing organs are preserved. This fact, coupled with their being found in the Carboniferous rocks, has suggested the name, which also serves to show their relation to living forms.

ANTHRACOPHAUSIA DUNSIANA sp. nov. Pl. IX., figs. 1–10.

Specific Characters.—Average size 30–40 mm.; general form elongated; carapace moderately long; rostrum moderately long, keeled, and falciform.

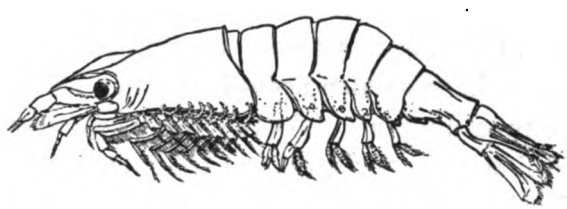

Fig. 2.—Restoration of *Anthracophausia dunsiana*, mag. 2 diameters.

General Description.—The form of the body is elongated, laterally-compressed, and prawn-like, and admits of a considerable amount of variation above what may be ascribed to state of preservation, the males being invariably more elongated in form and

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proportionately in their rostra than the females. The integuments are very thin, smooth, and unornamented beyond the usual band bordering the thickened margins and strengthening keels of the web-like organs and the rostrum. The test, which is chitinous, is often filled in with radiating calcareous plates which at times destroy the texture.

The trunk, including the rostrum, makes up about one-third the length of the body. The carapace, seen sideways, as it is usually preserved, is roughly triangular, being much wider behind and produced into a sharp triangular rostrum in front, surmounted by a sharp keel which is continued inwards on to the gastric region of the carapace. There is a small orbital spine and a distinct antennal spine at the antero-lateral angle. There is a slightly-marked cervical fold, but it is often masked by the collapsing of the body of the mandible; the lateral wings or lappets of the carapace are bordered by a narrow double band which is continued round the well-rounded postero-lateral angles, and deeply re-entrant posterior margin. The carapace is only attached to the first few segments, and loosely covers the others, so that in most of the fossils it is usually found somewhat displaced relatively to those segments and their attached organs (figs. 2–4), but is not so much so as in the case of the fossil Lophogastrids and the long-tailed Squillid-like forms already described. The deep emargination behind leaves the dorsal part of the last trunk segment bare, while at the same time the side wings lap well back on to the epimera of the first tail segment (figs. 3, 4). They also appear to have extended rather further down the sides than in the modern pelagic forms of Euphausiidæ. The trunk segments, with perhaps the exception of the last, are soldered together, the latter alone forming a complete ring, all the others being deficient dorsally where covered by the carapace, while the sternal parts are strongly developed, so that the segments appear sideways as a series of wedges set at a considerable angle to the axis of the body, the angle becoming more and more acute in the more anteriorly-placed segments (fig. 1). The tail, which is made up of the usual six segments and telson, is slightly fusiform, attaining its greatest depth about the second or third segment and tapering gently backwards to the base of the tail fan, each segment becoming in succession slightly longer than its predecessor, there being a sudden accession in the sixth segment, which is nearly double the length of the preceding one. As the third segment is considerably longer measured along the mid-line of the back than at the fulcra, the tail, when extended, has a natural arch at the third segment (figs. 1, 2). All the tail segments are well facetted and pivotted for rolling, and supplied with epimera which are deep and all overlap each other in regular backward order. Those of the first segment are considerably shorter than those of the second, and are overlapped in front by the hind lappets of the carapace; those of the second are larger and deeper than the succeeding ones, and are not so much

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bent backwards; their front margins bulge somewhat in front of the pivot. The succeeding ones are each in turn less deep and more directed backwards. Those of the sixth segment are small and do not extend to the posterior margin. All have a thickened band or facet where overlapped.

The telson, which does not extend to the tip of the external branch of the uropods, is heart-shaped, with a tumid base and applanated posterior region, which is fluted by a mesian depression flanked with carinated ridges and ends in a median elongation, and is probably supplied with a pair of narrow articulated plates or accessory swimmerets at the base of the terminal lobe, like those of the modern Euphausiids (figs. 5, 8).

The eye is large, and is usually seen in a crushed state lodged in its socket near the inner angle of the rostrum. The antennular peduncle is enormously developed, strongly resembling those of the modern congeners of the species. The proximal joint is the largest and is flattened and hollowed out, and bent up near the base to form, with the anterior margin of the carapace and the wings of the rostrum, a very efficient protecting socket for the eye. Beyond the hollow for the eye the joint becomes nearly cylindrical and extends to near the tip of the rostrum. The middle joint is much shorter than the former one, and is oblong when flattened and traversed by a longitudinal ridge. The distal joint is the shortest and is contracted along the mid-line, and supports two short flagella; but it has not been observed which of the two is the longer. The antennal system is more like that of the true Caridea. Only the joint of the peduncle bearing the basal scale has been observed. The scale is of the ordinary caridean type, with an external strengthened part ending in a tooth or spine, the inner being fimbriated and set with setæ. Along the edge there is a transverse suture and a terminal fimbriated lobe fringed with setæ, the end of the scale extending to the tip of the rostrum. The peduncle of the lash is three-jointed, the proximal joint being narrow and wedge-shaped. The other two are elongated and of about equal length, but do not extend as far as the tip of the scale. The flagellum is much more massive than those of the antennules, and also much longer; but the exact length has not been made out, as they are generally insufficiently preserved. The body of the mandible is large and set at an acute angle to the axis of the body. Its presence is nearly always conspicuously shown by its collapse; but the details of the cutting and molar parts have not been observed. The palp is long and slender and three-jointed, and is well seen in fig. 3 as it lies outside the body and free from the other members. The first or proximal joint is as long as the other two combined. The maxillæ are unobserved. The maxillipede, known only by its endopodite, is the most massive limb of the trunk (figs. 1, 2, 3). Four of its joints are often exposed; the tip joint is heart-shaped or

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spatulated, and flexes backwards with the next joint, which is subquadrate in form, flattened laterally, and with a strengthening keel. This joint also flexes back upon a long joint, longer than the two combined. This joint is laterally compressed and has a longitudinal strengthening keel. It is bent upwards and flexes forwards upon the fourth observed joint, making a sort of elbow with it. This joint is short and flexes forwards upon a fifth short joint of similar character seen in fig. 3. The whole construction of this limb reminds one powerfully of the limbs in the family of the Perimecturidæ, already described, and looks more like a raptorial limb than a gnathopod. The nature of the exopod of this limb has not been observed. The legs consist of seven pairs, all constructed much alike, but diminishing in size in backward succession as seen in fig. 1. The limbs are slender and arranged so that all the proximal joints of each leg flex forward; the distal joints flex backwards at the same relative joints in each leg. The tip joints are short and somewhat pointed, and flex back upon a longer joint, this in turn flexing also back upon a short joint which flexes back upon a long upturned one. The three combined joints are about equal in length to this long one. The long joint flexes forward on a short joint, making an "elbow," and this joint in turn flexes forwards upon a second short one; but the limb can be traced no further, owing to the swollen bases of the exopodite hiding what is probably the coxal joint. These limbs are pitted along their margin for setæ, and there can be no doubt that they agree in almost every respect with the more anterior limbs in *Euphausia*, but, unlike that genus, all the seven pairs of limbs are alike except in size. All are supplied with exopodites, the muscular basal joints of which are generally visible; but whether they ended in swimming plates or lashes has not been determined. No breeding lamellæ or brood pouch have been observed in the females, nor have gills with certainty been recognised; but the small round luminous organ has been observed on the last body segment in several specimens (figs. 1, 2, 5). The most notable character about the appendages of the tail is the enormous development of the limbs on the first two tail segments in the males, which are even more massive relatively to the size of the form and to the other pleopods than in the recent members of the family. The first pair are especially massive (figs. 1, 4), and consist of a strong, forward-curved, basal joint, to which is articulated a second joint which is either bifid or nearly so, and gives two branches. The inner branch terminates in a scoop-shaped plate, from the inside of which project coupling hooks. Two of these are shown projecting beyond the doubled up plate in fig. 1, a further magnified part in fig. 1[B]. The details of the arrangement of hooks have not been made out from the available material, but sufficient can be seen to show that these ancient forms had the same habit as their recent congeners of

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hooking spermatophores upon the females. The external branch appears to be in the form of an ordinary swimming plate. The pleopods of the second segment, although not quite so massive as those of the first, are very large and long, and appear to be even more complex. Each has a basal joint to which is articulated a second joint, which in turn supports two moderately long branches of two or three joints each, the details of which have not been ascertained (fig. 4). They appear to be more limb-like and primitive than the terminations of the first pair, and still more so than the corresponding parts of the recent Euphausiids, but unfortunately their state of preservation is not such as to allow of their structure being made out with certainty. (There appear to be other differences between the males and females than that of the pleopods, for the females seem to be as a general rule shorter and more stoutly built than the males). The pleopods of the third segment have much less massive basal joints, and appear to terminate in the ordinary applanated jointed swimmerets (fig. 1). Those of the fourth and fifth tail segments have not been observed, but they were presumably of the type of the pleopods of the third. Small round-shaped bodies have been observed on the sternites of the first four tail segments between the insertion of the bases of the pleopods in exactly the same position in which the luminous organs occur in the modern *Nictiphanes* of our own sea lochs (figs. 1, 2). One of these organs is shown magnified in fig. 1[A]. The uropods are well developed and almost caridean in construction. They consist of the ordinary basal joint attached to the sixth tail segment to allow the uropods to act with the telson and its appendages as a tail fan. The external branch of the uropod has the usual thickened outer margin terminating in a spine. The inner part is, as usual, more web-like, and there is the familiar transverse suture with the terminal lobe fringed with setæ. The internal branch is the ordinary linguate form with the median strengthening keel, and is a little longer than the telson, while the external branch is slightly longer still. Fig. 9 shows an enlarged restoration of this tail fan, and fig. 16, also enlarged, is that of the recent *Euphausia pellucida* Dana, for comparison.

In many of the specimens the course of the gut, distended with food, is distinctly traceable through the whole of the tail segments, as seen magnified in figs. 1, 6, and in fig. 8, also magnified, the position of the anal opening is shown in a sulcus situated in the hollow joint behind the tumid base. It also shows the terminal lobe of the telson and the articulations for its accessory swimmerets.

Remarks.—The distention of the gut with food found in many of the specimens from this locality appears to point to some external catastrophe or to epidemic disease being the cause of death—probably the former, as the remains of shoals of nearly complete individuals are found in certain layers. The shales in which they lie

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embedded are near the base of the Cementstone Group (Tuedian) of the Merse of Berwickshire, and not far above the horizon of the Kelso Volcanic Plateau. The Langholm scorpion-bed, which has yielded such a large suite of well preserved Schizopods and other crustaceans, often with the gut distended, is interbedded in a volcanic series at a higher horizon in the Calciferous Sandstone Series, while the bed of shale at Gullane, on the shores of the Firth of Forth in Haddingtonshire, on a corresponding horizon and connected with the great volcanic plateau of the Garleton Hills, has yielded an abundance of almost perfectly-preserved specimens of the genus *Tealliocaris*. Beds of fine ash are intercalated in the Wardie Shales at about the same horizon. In all these cases the beds that have yielded the crustaceans in shoals in the same layer have also yielded whole fishes often in great abundance. It looks as if the constant association of these beds, richly charged with nearly perfect remains of such fragile creatures, with volcanic conditions, were more than a coincidence, and that the waters were periodically poisoned by volcanic gases, so that both the crustaceans and their natural enemies the fishes met a common fate; otherwise it is difficult to conceive that the fishes would not have preyed upon the dead before their entombment. The attitudes assumed in dying by some of the fishes and the crustacea have already suggested the same idea.

The specific name is derived from Duns, Berwickshire, near which the fossils were obtained.

Locality.—Whiteadder Water, near Duns, Berwickshire.

Horizon.—Near base of Cementstone Group ("Tuedian"), (Scottish) Calciferous Sandstone Series.

Collector.—A. Macconochie.

ANTHRACOPHAUSIA DUNSIANA, var. OBESA var. nov. Pl. IX., figs. 11–15.

Remarks.—Among the numerous remains of this species from this locality there is a considerable range in form. As has been already stated, the females are more massively built than the males, but there is a greater variation than can be accounted for by sex. For instance, fig. 11 is undoubtedly that of a male in which not only is the body altogether stouter, but there is a considerable difference in the proportions of the carapace, which is shorter and much deeper in proportion to its length. The rostrum is also shorter and more curved, and the peduncles of the antennæ seem to be much more massive. Fig. 12 shows what is probably a female of this variety in which the luminous organs on the tail segments are indicated through the integuments.

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Specimens agreeing in most respects with the present variety are not uncommon in the Langholm scorpion-bed, but they are very poorly preserved. None of the elongated forms, however, occur among them. It is therefore possible that the Langholm form may represent a separate species, especially as the Langholm scorpion-bed occupies a much higher horizon than that from which the parent species was unearthed, the interval that separates them probably representing a long lapse of time. For lack of better-preserved specimens, they are provisionally placed under this variety.

Locality.—Same as last; also Scorpion-bed, Glencartholm, near Langholm.

Horizon.—Calciferous Sandstone Series.

Collector.—A. Macconochie.

ANTHRACOPHAUSIA TRAQUAIRI (B. N. Peach). Pl. X., figs. 1–5.

1882. *Anthrapalæmon traquairii* B. N. Peach, Trans. Roy. Soc. Edin., vol. xxx., p. 80, pl. x., figs. 5a–5e.

Remarks.—After the publication of the description of the present species in 1882, and immediately following upon the publication of the Report on the Challenger Schizopods by G. O. Sars, the well-preserved specimens of the type species of this genus were discovered by Mr. Macconochie. On studying them, it became apparent to me that I had made a great mistake in my original description of the present species, and that I had figured two quite different types of Schizopods under the name of *Anthrapalæmon traquairii*. Fig. 5 of my original description belongs to a member of the newly-erected family of the Perimecturidæ, while all the other figures represent a large species of the present Euphausiid genus, for which I retain the specific name. It therefore becomes necessary to give a general description of the species, although very little fresh material has been collected.

General Description.—The body is large, measuring 80–100 mm. in length, and correspondingly stout; it is laterally flattened, prawn-like, and fossilises sideways. The test is thin and smooth.

The trunk, counting from the tip of the long carapace, is nearly half the length of the body. The carapace, seen sideways, is short, triangular, and nearly equilateral, and produced into a rostrum as long as any side of the triangle. The rostrum is narrow and straight at first, and then bends downwards near its anterior end. It is of bayonet-form, having a decided crestal keel as well as lateral ones. There appears to be both

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an orbital and an antennal spine. The postero-lateral angles are rounded off. The posterior margin is only slightly hollowed out, nevertheless it does not cover the dorsal part of the last trunk segment. There is only a slight indication of a cervical fold, and the only ornament is the narrow double border to the side lappets and the posterior margin. The trunk segments are incomplete along the back, and, seen sideways, they appear as wedges as in the former species. This is well shown in fig. 3, where the carapace is broken away.

The tail is incomplete and only part of its six segments preserved, but it is remarkably prawn-like, especially when seen in relief as in the specimen shown in fig. 3. The first segment is short and deep, with deep narrow epimera pointed downwards and backwards, which are evidently overlapped by the posterior wings of the carapace when the tail is folded up. The second segment is larger than the first, and is provided with similar pointed epimera, and there is not so great a disparity in size between those of the two segments as usual. The third segment is longer along the line of the back than the second, and seen sideways is more wedge-shaped than it, indicating that there was the same habit of arching the back as in *Anthracophausia dunsiana*. The epimera are also pointed and directed backwards. The next three segments are incomplete, but sufficient is shown to see that they diminish rapidly in depth successively, showing that there was considerable taper of the tail. Sufficient of the epimera of the fourth and fifth segment are preserved to show that they were deep and pointed and set backwards like the preceding ones. There appears to have been a ridge along the back of the sixth segment. The only ornament on the segments are slight transverse bands on the anterior parts of the tergites and the thickened facets on the anterior edge of the epimera, which all overlap each other in the usual manner.

The appendages of the trunk are not well preserved. The eye is of moderate size, short stalked, and placed as in the former species. The peduncle of the antennule seems to be about the same length as the rostrum, and gives off two lashes, but their relative length has not been observed. The antenna has the basal scale of the same caridean type as in the former species. The flagellum is massive, and the peduncles shorter than the scale. The bodies of the mandibles are preserved *in situ* in the specimen that fig. 3 is taken from. The specimen is preserved uncompressed in a calcareous nodule. The bodies are tumid and massive, but the molar and biting parts are not exposed. The long basal joint of the palp of the mandible is seen outside the form, and appears to be much as in the other species.

The maxillæ have not been observed, but two joints of the massive endopodite of the maxillipede are seen in fig. 3. The long joint of the limb is massive, carinated

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longitudinally, and set with a row of bristles along its posterior margin. Portions of several legs, all directed forwards, are visible, showing both endopodites and exopodites, but their number cannot be computed, as those of both sides of the body seem to be huddled up together. In the type specimens, the figures of which (figs. 1, 2) are reproduced from the original ones, the dorsal portions of several endopodites are shown which are constructed, not as in the true carideans, as was at first erroneously supposed, but as in *Euphausia*, and flex backwards at the articulations corresponding with those in the legs of that genus. A whole row of what are most probably the exopodites is shown in fig. 2, and one of the fragments lying behind the undoubted legs is evidently a portion of the swimming plate or lash of such an exopodite. No breeding lamellæ have been observed, but fortunately a portion of the gill has been detected, which is shown magnified in fig. 5, a reproduction of the figure in the original description, and which agrees in structure with the simple branching gills in the Euphausiidæ. Its position, in the specimen, just behind the rounded postero-lateral angle of the carapace, indicates that it is a branch of the gill of the last pair of trunk limbs, which in *Euphausia* is identical in structure with that figured by me in 1882, when the description was first given by me before the Royal Society of Edinburgh. Beside that figure I have placed for comparison a tracing of one of the figures, after G. O. Sars, of the magnified gill-branches from the corresponding last pair of trunk limbs of the recent *Euphausia pellucida* Dana (fig. 6).

Locality.—River Esk, Glencartholm, near Langholm, Dumfriesshire.

Horizon.—Scorpion-bed, Calciferous Sandstone Series.

Collector.—A. Macconochie.

Genus CRANGOPSIS J. W. Salter, 1863.

1861. *Uronectes* J. W. Salter, Trans. Roy. Soc. Edin., vol. xxii., p. 394.
1861. *Palæocrangon* J. W. Salter, Quart. Journ. Geol. Soc., vol. xvii, p. 531, fig. 8.
1863. *Crangopsis* J. W. Salter, Quart. Journ. Geol. Soc., vol. xix., p. 80.

CRANGOPSIS SOCIALIS J. W. Salter. Pl. X., figs. 7–11.

1861. *Uronectes socialis* J. W. Salter, Trans. Roy. Soc. Edin., vol. xxii., p. 394.
1861. *Palæocrangon socialis* J. W. Salter, Quart. Journ. Geol. Soc., p. 531, fig. 8.
1863. *Crangopsis socialis* J. W. Salter, Quart. Journ. Geol. Soc., vol. xix., p. 80.

Fresh light has been thrown on this species from the study of new material obtained from the original locality at Ardross, on the Fife shore, by Mr. Wm. Anderson,

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late Government Geologist for Natal, and generously presented by him to the Scottish Survey Collection.

General Description.—As in the other members of this family, the integuments are thin and smooth and the form of the body is long and laterally compressed, fusiform, and shrimp-like, so that it is generally found fossilised sideways. Although the test is thin, it is not quite so much so as in *Anthracophausia*, and the limbs are also somewhat more massive.

Seen in lateral aspect, the carapace is small and triangular and deeply emarginate behind, so that while the rounded postero-lateral parts act as lappets on the epimera of the first tail segment, the back of the last trunk segment is left bare. It is only slightly produced into a very short blunt rostrum in front, and there are blunt protuberances representing the orbital spines and at the antero-lateral angles. There is only a faint suggestion of a cervical fold; the carapace, owing to its thinness, becomes wrinkled and conforms to the shape of the harder internal parts when the specimen is compressed, as it is usually found. Fortunately, there is a certain amount of calcareous matter in the embedding rock, so that it appears to have set early after deposition, and some of the organs are preserved uncrushed. As in the other members of the family, the carapace is only in vital attachment with the segments bearing the head and mouth organs, and merely covers the other trunk segments loosely. The sole ornament is a narrow band round the side wings and posterior margin. These limb-bearing trunk segments, except the last one, are all incompletely covered in and soldered together, and, as seen laterally, are wedge-shaped, but are not set at so acute an angle to the general axis of the body as in *Anthracophausia*. The last trunk segment is comparatively free, and is completely covered in by strong test dorsally. The sternal parts of this segment are wide, and the articulation for the insertion of the limbs large, and far apart as seen in fig. 9, the original of which, as if in illustration of the statement made above, has parted from its fellows while it is still attached to its tail.

As seen in the above figure, the tail is massive, long, muscular, and fusiform, attaining its greatest depth about the second segment and tapering thence evenly to the base of the tail fan, the individual segments becoming increasingly long in backward succession All are supplied with epimera, which are rounded on the first four segments. Those of the first segment are comparatively small, and, as already stated, are overlapped by the side wings of the carapace and from behind by the anterior margins of the epimera of the second tail segment. These latter are large and rounded, and produced both forwards and slightly backwards, so that their posterior margins overlap on to the succeeding epimera. The epimera of the third segment are not so large as

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those of the second, and overlap on to those of the succeeding segment, and this order is carried out in backward succession, the epimera at the same time becoming smaller. Those of the fifth segment are bluntly pointed and directed backwards. Those of the sixth trunk segment are quite small and do not continue back to the posterior margin. The ventral parts of these segments are very firmly constructed, and the attachment for the pleopods large and somewhat far asunder. The last segment is closed in quite across the ventral part.

The telson is small and much shorter than the flanking uropods. It is tumid towards the base, flattened out behind, and divided by a median groove. Whether it is forked at the end or had a median terminal lobe there is no means of deciding from the specimens at command. It is probable that this projection existed, as it does in so many of its fossil and recent congeners. Articulations for the attachment of the small swimming plates are seen in specimen from which fig. 9 was taken. The position of the anal opening is also well seen placed just behind the swollen part of the telson.

The appendages of the trunk are well preserved in two of the specimens. The eye is large and the stalk very short, for the crushed cornea is usually to be found at the very front margin of the carapace. From the large area covered by the crushed cornea it may have been reniform, but there is not sufficient evidence to prove the point. The peduncles of the antennules are exceedingly large and massive, as they are in all the species of this genus, and are nearly as long as the carapace. The base of the proximal joint is hollowed out to receive the large eye, beyond which it becomes cylindrical, though it appears to be traversed longitudinally by ridges which were probably ciliated. The other two joints are short in comparison to the first, the terminal one being the shortest. The flagella are both very puny compared with the propodite, and were probably both short, though they are broken in the specimen that exhibits them. The antenna has the usual scale set upon a basal joint, the only part of the peduncle seen outside the carapace. The scale is caridean in structure, with the marginal thickening and spine, and with the terminal lobe set round its inner side and tip with setæ. It extends to just beyond the end of the first joint of the peduncle of the antennules. The peduncle of the flagellum of the antenna is long and slender. and extends beyond the tip of the scale. The flagellum is comparatively slender and only slightly more massive than the flagella of the antennule. The position of the body of the mandible is indicated as usual crushed up through the carapace. It is evidently set at a greater angle to the long axis of the body than in *Anthracophausia*, though considerably off the vertical, as might be expected when the shortness of the trunk is considered.

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What looks like the palp of the maxillipede is shown in fig. 8, where an organ with one longish massive joint with a thin continuation made up of several joints is visible. Were it not that the base of this organ is too large, it might be the palp of the second maxilla. It may not be that of the mandible, as it seems to arise considerably behind the body of that organ. It is just possible that it is the displaced exopodite of one of the legs.

The legs all seem to be constructed alike. The endopodites are all very massive and long and laterally compressed, with a longitudinal crest, and set along their posterior edges with a row of setæ. The tip joint is spatulate and short, and flexes backwards on the next joint, which is also short, but longer than the tip joint. It also flexes back upon a third joint, which is long. The length of leg may be guessed by the fact that the articulation between the second and third joint reaches as far forward as the tip of the proximal joint of the antennule. The legs become slightly shorter in backward succession, but even that of the seventh trunk segment is of the same type as the others. The exopodites of these limbs are seen in fig. 7 to be of the usual type, viz., with a thickened fleshy base and ending in a many-jointed plate or lash. Fragmentary structures resembling broken gills are seen near the base of the last trunk limb in fig. 8.

The appendages of the tail are only moderately well preserved. Those of the two first segments of a male are seen in fig. 9 to consist of a very massive basal joint. The second joint is not very well preserved, but to judge from what is shown, it was modified in the usual way for coupling the spermatophores on to the females. The pleopods of the second tail segment are modified similarly to those seen in *Anthracophausia*. There is the same long basal joint followed by a second longish joint which supported a much thinner cylindrical branch, one joint of which is seen in fig. 7. Fig. 8 is apparently that of a female; all the tail limbs seen folded up together are supplied with swimming plates only. The basal joints of all these limbs are seen to be rather massive. The uropods of the sixth segment are long and slender, as seen in fig. 10. The basal joint is somewhat long, and the external branch long and blade-like with longitudinal strenthening keel, and this extends considerably beyond the tip of the telson. The inner branch has not been observed, and was probably shorter and of the usual linguate form. Fig. 11 is an attempt to reconstruct a male of this form twice the natural size.

Locality.—Ardross Shore, near St. Monans, East Fife.

Horizon. Abden Limestone, near top of (Scottish) Calciferous Sandstone Series.

Collector.—Wm. Anderson.

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CRANGOPSIS RHODESI sp. nov. Pl. XI., figs. 11–14.

Specific Characters.—Small slender form a little over 10 mm. in length. Carapace long and narrow, deeply emarginate behind and with a broad band bordering its side wings and the posterior margin. Epimera of tail segments obtusely pointed and directed backwards. The epimera of the second tail segment do not overlap on to those of the first. Peduncle of antennules long and slender.

General Description.—This is an elegant shrimp-like form with elongated body, laterally compressed, and fossilising sideways. The integuments are thin and smooth, but usually much wrinkled in the fossil state.

In the trunk, the loosely attached carapace is narrow and elongated, measuring considerably more than one-third of the length of the body. There is only a very slight peak in front corresponding to the rostrum, but there appears to be a slight crestal keel, and a blunt projection in the place of the orbital spine and one also at the antero-lateral angle. The wings are extended far back, the postero-lateral angles being well rounded, and the carapace is usually deeply emarginated behind. The wings and the posterior margin are bordered by a characteristic, somewhat broad, double border which serves to distinguish fragments of the carapace of this species from some of the others. Owing to the length of the trunk the segments composing it are set at a somewhat more acute angle to the axis of the body than in any other species of the genus.

The tail is of the usual fusiform shape, being deepest about the second segment and tapering gently backwards. The segments increase in length in order backwards, and the last segment is nearly double as long as any of the others. They are all supplied with deep epimera with blunt pointed ends directed slightly backwards. Those of the first segment are well overlapped by the wings of the carapace. Those of the second segment are the deepest and longest, but they do not overlap on to the posterior margin of the epimera of the first segment as in the case of several species of the genus. The epimera of each segment only overlap on to those of the succeeding segment in rotation backwards. They also diminish in depth in succession from the second segment, and are only slightly represented on the sixth segment.

The telson is comparatively short, is grooved down the mid-line, and produced into a terminal lobe beyond its constricted part, where the two small accessory plates or swimmerets are articulated with it. It differs from that of *C. socialis* in having its antero-lateral angles ornamented with a thickened band ending in a backwardly-directed spine on each side at about one-third of the distance from the base to the tip (fig. 12).

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The eye is relatively smaller than in *C. socialis*, but evidently placed in the same relative position beneath the pent-house formed by the blunt rostral protuberance and the fold of the test representing the orbital spine.

The antennules have a long peduncle as shown in fig. 11, but not so long relatively to the carapace as in the type species. It may be as well to mention here that the shale in which the fossils are embedded has been subjected to some sort of interstitial movement of its particles, so that the forms which are orientated with the longer axes more or less conforming with the direction of movement are abnormally elongated, and those that lie athwart that direction are equally abnormally broadened. A mean has therefore to be struck between the two in studying the proportions. In the form that lies across the direction, the length of the peduncle of the antennule is not affected. Notwithstanding its abnormal broadening it is not so massive as that of the type species. The basal joint is much the longest. The second joint is longer relatively to the basal joint than in the former species; the top joint is also elongated and supports two flagella of about equal length and about half the length of the peduncle. Of the antennary system the distal joint of the basal part is longish and extends well in front of the carapace. The scale is long and comparatively narrow and caridean in construction, with strengthening keel and spine, and extending to beyond the end of the second joint of the antennular peduncle. The peduncle of the flagellum is not so long as the scale, and the flagellum is moderately slender, and longer than those of the antennule. The body of the mandible is seen to be in place in fig. 11 by the bulge it makes beneath the carapace and not by being crushed in. The palp is seen in the same figure between the basal scale and the crushed limb, but its details are not sufficiently well preserved. The maxillæ are unknown. The maxillipedes and legs are seen all crushed up together. The exopods of at least seven legs are shown. The endopodites must have been long, especially those of the last trunk segments. The distal joint of none is exhibited, as all the limbs are obliquely truncated in the one specimen. The other specimen shows the bases of seven or eight limbs on the one side, the other joints being removed. The most interesting structures preserved in this part of the trunk are the brood pouches with enclosed eggs or larvæ as shown in the broadened specimen in fig. 11. These occur just beneath the posterior lappet of the carapace and behind the base of the forwardly directed legs of the last trunk segment; but the carapace is somewhat displaced relatively to the tail, while the tail itself is broken and pushed forward upon itself. The brood pouches, notwithstanding, are in their proper relative position where they might be expected to occur. They are placed relatively where the egg-sacs of the recent *Nictiphanes* are found. If they represent

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those structures they are split up and their contents are partly scattered. Egg-sacs with ova are shown in another species of this genus (pl. xii., fig. 8.)

The pleopods of the second tail segment are shown in fig. 11, and seem to be of the ordinary construction. The uropods are considerably longer than the telson, and are quite shrimp-like in construction.

Fig. 13 is the restored tail magnified, and fig. 14 is an attempt at a restoration of this beautiful opossum shrimp a little over three times the natural size.

Remarks.—Although the specimens were not found in Scotland they form part of the Jermyn Street collection, and have been made use of in the present memoir. They were collected by Mr. John Rhodes, whose name I wish to associate with this elegant species.

Locality.—Chattlehope, Rede Water, Northumberland.

Horizon.—Cementstone Group (Tuedian), (Scottish) Calciferous Sandstone Series; (English) Carboniferous Limestone.

Collector.—J. Rhodes.

CRANGOPSIS MAGNA sp. nov. Pl. XI., fig. 15.

General Description.—The remains, as may be seen from the specimen, are those of a male. To judge from the portion of the carapace preserved, which shows only the hinder end of the wing or side lappet, it must have been shorter and deeper in proportion than in *C. rhodesi*, and also differed from it in having only a comparatively narrow plain bordering band.

The tail is constructed almost identically as in *C. rhodesi*, but is more massive relatively to its length. The epimera are deep, narrow, and pointed backwards, and those of the second segment are not carried forward on to those of the first. The telson is much as in *C. rhodesi*, and similarly ornamented along its antero-lateral parts, but appears to be shorter relatively to the uropods than in that form.

None of the appendages of the trunk have been observed, and, except the uropods, the only tail appendages are the enormously developed pleopods of the first and second segment, which show that the specimen is a male. Only the basal joint of the first pair are seen, but they are long and massive. Three joints of one of the second pair are shown.

Remarks.—This name is proposed for a large form which must have measured 45–50 mm. at least. It belongs to the same group of species as *C. rhodesi* and *C. couttsi* in the arrangement of the epimera of its tail segments, and might almost be considered a variety of the former, from which, however, it differs in proportions as well as in size.

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Several fragments of the form occur in the collection, all from the same locality, but fig. 15 represents in natural size the least incomplete specimen, though some of the fragments show that members of the species must have attained a still larger size.

Locality.—Glencartholm, Langholm, Dumfriesshire.

Horizon.—Calciferous Sandstone Series.

Collector.—A. Macconochie.

CRANGOPSIS COUTTSI sp. nov. Pl. XII., figs. 1–7.

Specific Characters.—Moderately large shrimp-like forms, 30–50 mm. Carapace more than one-third of length of body, deeply emarginate behind, and with rounded lappets edged with double marginal band, produced slightly in front into a short and broad triangular keeled rostral protuberance marked off by a depression bridged by the keel, which extends back over part of the gastric region; only faint trace of a cervical fold. Antennular peduncle long and massive. Epimera of tail segments bluntly pointed and directed slightly backwards; those of second segment do not overlap forwards on to those of the first. Telson nearly as long as the uropods, and embossed with two heart-shaped keeled areas, one on each side of the median depression.

General Description.—This is a moderately stout, shrimp-like form, with laterally compressed body so that it fossilises sideways, and its thin integuments are generally much wrinkled.

The trunk, which makes up more than one-third of the body length, is evidently constructed much on the lines of the previously-described species, though somewhat shorter and stouter in its proportions. The carapace is of the usual form, and seen sideways it is almost rhomboidal, being a little deeper behind than in front. It has rounded posterior angles, and is moderately deeply cut out along the back, leaving bare the last trunk segment in the mid-line. It is edged along the sides and behind by a double thickened band. In front, it is produced into a wide triangular protuberance in place of a rostrum, and has wide and short orbital and antennal spines. The rostral triangle is surmounted by a distinct central keel, which, extending back and bridging a depression, is carried for a short distance on to the gastric region of the carapace, where it dies down. The tail is of the usual fusiform shape and somewhat stoutly built. It attains its greatest depth about the second or third segment, and the segments increase in length while they decrease in depth successively backwards, the sixth segment being the longest, narrowest, and shallowest. All are supplied with epimera, which are deep and directed downwards and backwards and terminate in rounded narrow points. The epimera of

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the first segment are comparatively small, and are overlapped only by the postero-lateral extension of the carapace, while they in turn overlap on to the epimera of the second segment. Those of the second segment are the largest and deepest of all, and in turn overlap on to those of the third, and this order is maintained by all the others in succession, the epimera at the same time decreasing in depth in the same order. The segments are well facetted along the anterior part of the tergites for rolling, and along the antero-lateral sides of the epimera to allow of overlapping.

The telson has the usual tumid basal part in front, is applanated behind, divided down the median line by the usual broad groove, and terminates in a small pointed lobe. On each side of the central groove a narrow fluted and keeled heart-shaped area in bas relief extends from near the anterior margin back so far that the pointed end terminates at the base of the median lobe, where it forms the articulation for the accessory swimmerets. These are moderately large, linguiform, and have a median strengthening keel. They are curved gently outwards, the margins being set with setæ.

The appendages of the trunk that have been observed are as follows:—The eye is large and short-stalked, and is usually found crushed lying partly overlapped by the broad wings of the short rostral protuberance (fig. 5). The antennular peduncle is extremely massive. The long proximal joint is hollowed out and flattened for the eye, and then becomes cylindrical, but bears a slightly crenulated ridge, which was probably ciliated. The mid-joint is subquadrate as seen crushed, and the terminal joints still smaller and narrower, and gives off two flagella of nearly equal length, the external one being somewhat the more massive of the two. Two joints of the base of the antenna are shown in fig. 2, the carapace being broken away. The proximal joint is long and massive, but as only the upper side is exposed there is no opportunity of observing whether it is pierced for the opening of the "green gland." The second joint is smaller and bears the scale, which is long and of the usual construction, with strengthening keel spine. It extends to the end of the second joint of the antennular peduncle. The peduncle of the flagellum is slender and long-jointed, and about as long as the scale. The flagellum has not been observed. Only the bases of the trunk limbs have been observed. Seven of these are shown in fig. 1.

Of the appendages of the tail, only the pleopods of the first two segments and the uropods have been observed. The pleopods of the first and second segment (fig. 1) are fortunately those of the male, which are of the usual massive type and evidently modified for sexual purposes, but the details of their distal joints is not shown. The basal joints, however, are particularly massive and muscular. The uropods are of the usual type and call for no special notice, except that they extend a little beyond the tip of the telson, as seen in figs. 3 and 4.

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Remarks.—The specimens that were used by me for the above description and figures were collected by the late Mr. Andrew Patton, the manager of the Calderwood Cement Works, east of Kilbride, in Lanarkshire, and formed part of the collection of the late Mr. James Coutts, of Glasgow, who kindly let me have the use of them for study, and after whom I propose to name the species. At Mr. Coutts' death some of them were acquired by the Royal Scottish Museum and are in that collection, and others were bought by the late Dr. Hunter, Selkirk, whose collection was willed to the Museum of Kilmarnock, Ayrshire. They are embedded in a fine calcareous shale, and are in a very good state of preservation. An attempt at restoration of the parts observed, magnified about two diameters, is given in fig. 7.

Locality.—Cementstone Quarry, East Kilbride, Lanarkshire.

Horizon.—Lower Limestones, (Scottish) Carboniferous Limestone Series.

Collector.—Andrew Patton.

Crangopsis robusta sp. nov. Pl. XII., figs. 8–12.

Specific Characters.—Small, stoutly-built, shrimp-like form 15–20 mm. in length. Carapace less than one-third of the length of body; not much hollowed out behind, and with either no rostrum or only a very inconspicuous one. Epimera of first tail segments larger than usual, and only partly overlapped by the wings of the carapace, and with posterior margins overlapping on to epimera of second segment. Telson much shorter than uropods.

General Description.—This is another shrimp-like organism, laterally flattened, and fossilising sideways. It is small, measuring from 15–20 mm., and that this is the size of adults is shown by one of the specimens carrying an ovisac distended with ova (fig. 8). The carapace, seen doubled and in side view, is of the usual triangular or roughly rhomboidal shape, being much deeper behind than before. It is short and plain, and with only the narrow thickened border for ornament. No rostrum has been observed, although there is the projection formed of a flap over the eyes, which are moderately large. As seen in fig. 1, the last body segment forms a complete ring, and the penultimate segment retains a portion of its dorsal covering.

The tail is of the usual fusiform shape and tapers back from the second joint. The last segment is markedly the longest. All the segments are strong and well put together, being well facetted for rolling and provided with epimera, which are not so deep proportionately as in most of the other species. As already mentioned, those of the first segment are larger than usual, being rounded and produced forward in front as well as

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backward (fig. 11). They are only slightly overlapped by the wings of the carapace. Their posterior margins overlap on to the epimera of the second tail segment, which are directed slightly backwards and end in rounded backwardly-directed points, as do those of each succeeding segment, becoming smaller and smaller successively, each being overlapped by its predecessor.

The telson is of the usual type, tumid and broad at base and flattening and tapering backwards, divided into two raised areas by a central groove, and ending in a pointed lobe flanked by small accessory swimmerets. Its details, taken from several specimens, some of them not figured, are shown magnified in fig. 10. The eyes are moderately large and placed close up to the edge of the carapace. The antennular peduncles are long and not so massive relatively as in some of the other species. They are constructed of the usual three joints, and end in two moderately long flagella. The antennal scale is of the usual type and nearly as long as the propodite of the antennule. The peduncle of the antenna is not quite so long as the scale.

What appears to be the palp of the mandible is seen in one of the specimens pressed up against the base of the antenna. The bases only of the trunk limbs are shown, but in one specimen (fig. 8) an ovisac distended with either large ova or larvæ is seen underlying the last two trunk segments. In this specimen the pleopods of the first four tail segments are also shown, and consist of the usual basal joint, which extends to beyond the tips of the epimera, and the two terminal swimming plates. The uropods are of the usual type, and call for no further remark than that they extend considerably beyond the tip of the telson. The tail fan is therefore a somewhat elegant object, as in shown in fig 10.

Remarks.—This pretty form occurs in great abundance, and sometimes several may be seen on the same slab. As will be observed from figs. 8 and 9, which are natural size, the course of the distended gut is seen very prominently. This is the general rule with these fossils at the locality where they were found. Fig. 8 shows one adult female with brood sack attached which also has the gut distended with food; this looks as if she were in a good enough state of health when she met her death, and that she did not lie long exposed before being embedded. A point, favouring the theory of wholesale destruction at one and the same time, is that the remains seem to be phosphatized, as also are the well-preserved specimens of *Tealliocaris* at Gullane. According to Sir John Murray, phosphatic nodules are forming on the Aghullas Banks, where wholesale destruction of fish and other forms of life often occurs through slight shifting of the cold currents on to areas usually occupied by warmer water.

In fig. 12 a magnified restoration of the parts observed of this compact form is given.

Locality.—Coomsdon Burn, Rede Water, Northumberland.

Horizon.—Calciferous Sandstone Series.

Collector.—J. Rhodes.

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CRANGOPSIS MINUTA sp. nov. Pl. XI., figs. 16–18.

Specific Characters.—Very small form, resembling the last species, but only 5–8 mm. long; carapace more than one-third the length of body; telson very short, not half the length of that of the uropods.

General Description.—This small form resembles *C. robusta* in many respects, but is altogether more slender in its build. Its carapace is longer and narrower relatively to the rest of its body. The tail is constructed in the usual manner, and each segment bears epimera. The sixth tail segment is especially long and narrow. The telson is also constructed after the manner of the preceding form, but is much smaller relatively to the uropods.

The eyes are large and conspicuous, and are usually found at the edge of the carapace, which is without any conspicuous rostrum, while a fold is usually seen just behind the eye. This should not be confounded with the cervical one. The antennule is, as usual, largely developed and conspicuous; there is the usual massive peduncle in three joints, the proximal joint being longer than the other two combined. The peduncle ends in two short flagella. The antennal scale is rather broader and not so long relatively as in the former species. The flagellum of the antenna has not been observed, neither have any of the other appendages of the trunk.

In the appendages of the tail there seems to be the usual difference in the pleopods of the first two segments in the different sexes. Fig. 16 shows what is evidently a male, and fig. 17 a female. In the former case the basal joints of the first two pairs are much larger than the others, while in the latter case those of the second tail segment are not so appreciably larger than the three succeeding ones. The uropods are of the usual type, but, as already stated, they extend far beyond the tip of the telson (fig. 18).

Locality.—Coomsdon Burn, Rede Water, Northumberland.

Horizon.—Calciferous Sandstone Series.

Collector.—J. Rhodes.

CRANGOPSIS ESKDALENSIS (B. N. Peach). Pl. XI., figs. 1–7.

1882. *Palæocrangon eskdalensis* B. N. Peach. Trans. Roy. Soc. Edin., vol. xxx., p. 84, pl. viii., figs. 9–9i.

Remarks.—There are a great many specimens of this form in the collection of the Geological Survey of Scotland collected by Mr. Macconochie, some slabs being crowded with them, but there are not any in better state of preservation than those made use of for

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the original description. These, however, looked at in the light obtained from the study of the well-preserved specimens of *C. socialis* from Ardross, show that such organs as are preserved are more similar to those of the Euphausiidæ than to the corresponding organs in the macrurous Decapods to which I originally assigned the form. By permission of the Council of the Royal Society of Edinburgh, some of the original figures of the species are here reproduced. In figs 2, 3, 5 the massive nature of the peduncles of the antennules is more in keeping with those of the Euphausiidæ than those of any Decapod. The antennary system is of the ordinary caridean type, and thus is of no avail as evidence. In fig. 2 the portion of the limb there shown flexes as in the Euphausiids, and is either the palp of the maxillipede or one of the limbs of the last seven trunk segments. But it is in the pleopods of the first two tail segments in the male form represented in figs. 2 and 3 that the Euphausiid character is most observable. Fig. 6 is evidently one of the first pair peculiarly modified for coupling spermatophores on to the females, and it was a mistake to compare it with its homologue in *Astacus*. The telson is also quite Euphausiid in construction. The most pronounced specific character is shown by very much enlarged epimera of the second tail segment, which overlap those both in front and behind, and further on to the former. *Locality.*—Langholm, Dumfriesshire.

CRANGOPSIS ELEGANS (B. N. Peach). Pl. XI., figs. 9, 10.

1883. *Palæocrangon elegans* (B. N. Peach). Trans. Roy. Soc. Edin., vol. xxx, p. 515, pl. xxviii., figs. 8, 8a.

Remarks.—There are several specimens belonging to this graceful little form in the collection. The best preserved are from the Whiteadder Water at Pathhead Mill, near Duns, in Berwickshire, where they lie entombed in shoals. They also occur sparingly along with *C. eskdalensis* in the Scorpion-bed of Langholm, in Dumfriesshire, at a somewhat higher horizon. Among the material from Duns are several specimens showing the massive peduncle of the antennules so characteristic of the Euphausiidæ (fig. 10). In the nature of the epimera (fig. 9) this form stands intermediate between the two groups into which this genus naturally divides itself.

Locality.—Whiteadder Water, Pathhead Mill, near Duns.

Horizon.—Near base of (Tuedian) Cementstone Group, Scottish Calciferous Sandstone Series.

Collector.—A. Macconochie.

[1] Peach, *Trans. Roy. Soc. Edin.*, 1882, vol. xxx., p. 85.

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CRANGOPSIS HASTATA sp. nov. Pl. XI., figs. 19, 20.

Remarks.—Among the material obtained by Mr. Rhodes from the Cementstone Group of the Lower Carboniferous rocks of Redesdale, Northumberland, there are the tail fans of what appears to be a species in which the telson, while having a strong general likeness to those of the present genus, and more particularly to those of the second group into which it is divisible, differs considerably from any as yet described. The difference is one of degree and not of kind, for it consists chiefly in the greater elongation of the terminal lobe, which is produced into a spear-shaped protuberance as long as the body of the telson. Accompanying this strengthening, the accessory swimmerets are longer than usual, and this general lengthening is also shared by the uropods, especially in their terminal branches. Should further search result in the finding of more complete individuals, they will in all probability be classed with the members of the second group, wherever that may be placed.

The specific name is suggested from the shape of the projection of the telson. Fig. 19 shows the tail fan from above. Fig. 20 is from a specimen seen sideways and from beneath; both magnified about 4 diameters.

Locality.—Chattlehope, Rede Water, Northumberland.

Horizon.—Cementstone Group (Tuedian), (Scottish) Calciferous Sandstone Series.

Collector.—J. Rhodes.

The species of the genus *Crangopsis* as constituted in this memoir naturally fall into two groups, viz.:—

I. Those in which the epimera of the second tail segment are large and rounded, and overlap on to the epimera of the segments both in front and behind it, including the following species:—(1) *Crangopsis socialis* Salter (type); (2) *C. eskdalensis* (Peach); (3) *C. huxleyi* (H. Woodward); (4) *C. elegans* (Peach).

II. Those in which the epimera of the second segment are more or less pointed and only overlap backwards on to those of the succeeding segment, including the species (5) *C. couttsi* Peach; (6) *C. rhodesi* Peach; (7) *C. magna* Peach; (8) *C. robusta* Peach; (9) *C. minuta* Peach; and probably (10) *C. hastata* Peach.

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EXPLANATION OF PLATES.*

PLATE I.

Figs. 1–7A. *Tealliocaris loudonensis* sp. nov. .. .. Page 9.

1. Seen from above, mag. 3 diam. The carapace has broken away, exposing the interior of the sternal region and showing the gills at the bases of the limbs: *e.* eye, *a.* antennules, *an.* antennæ, *s.* basal scale, *m.m.* molar part of mandible, *m.p.* mandibular palp, *epis.* espistome. Locality, Gullane Shore, Haddingtonshire. M. 84[F].

2. Mag. about 2 diam. Same locality. M. 4866[E].

3. Seen from beneath, mag. 3 diam.: *hy.* hypostome, other lettering as in fig. 1. Same locality. M. 4848[E].

4. Mag. 3 diam.: *o.p.* ocular papilla, *pl.* pleopods, *a.o.* anal opening. Shows also the sternites of the trunk and tail. Same locality. M. 4852[E].

5. Seen from beneath, mag. 3 diam., to show emargination of carapace in front of cervical groove for reception of epignathite on 2nd maxilla. Same locality. M. 4821[E].

6. Mag. over 3 diam., to show breeding lamellæ. Same locality. M. 77[F].

7. Mag. 3 diam., showing sternal part of trunk and appendages of head and trunk. Same locality. M. 4807[E].

7A. Same, mag. over 9 diam.: *e.* eye, *o.p.* ocular papilla, *a.* antennules, *an.* antennæ, *s.* basal scale, *epis.* epistome, *met.* metastome, *m.p.* mandibular palp, *max. I.* first maxillæ, *max. II.* second maxillæ, *mx.* maxillipedes, *en.* endopodites of the seven trunk limbs, *ex.* exopodites of same, *m.g.* openings of male genital organs, *p.l. I.* pleopods of first tail segment. The sternal branches of the gills and a peculiar epipodite are shown on the last seven trunk segments at the bases of the limbs.

* The registration numbers of the specimens collected by the Geological Survey are given immediately after the explanation of the figures.

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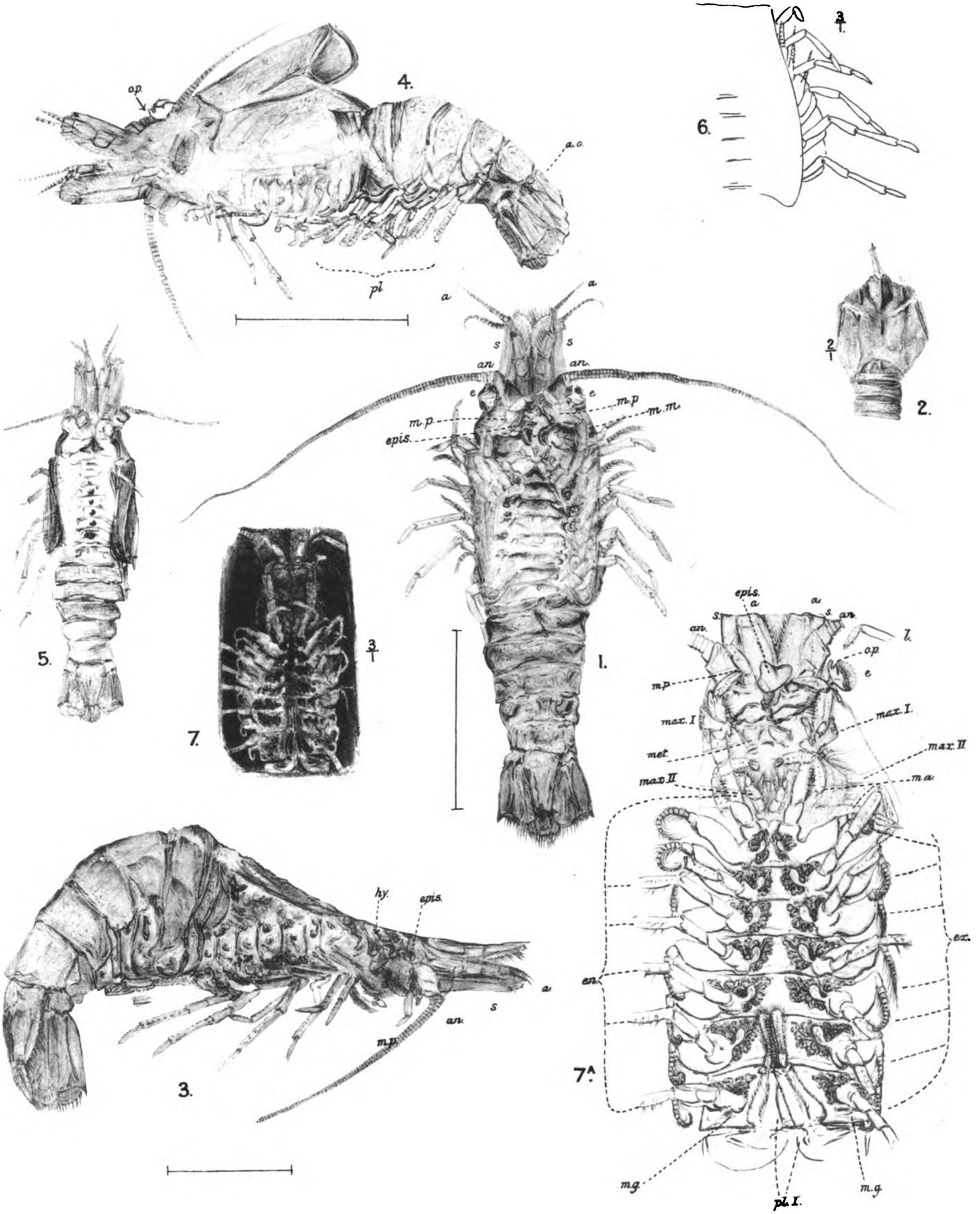

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PLATE II.

Figs. 1–6. *Tealliocaris woodwardi* (R. Etheridge, jun.) .. .. Page 18

1. Mag. 6 diam. Shows dorsal aspect, but integument so transparent as to allow sternal organs to be seen: *e.* eye, *a.* antennules, *an.* antennæ, *s.* basal scale, *m.p.* mandibular palp, *en.* endopodites, *ex.* exopodites of legs, *b.l.* breeding lamellæ. Shows tail with median and side keels, telson with terminal lobe and accessory swimmerets. Locality, Gullane Shore, Haddingtonshire. M. 4816[E].

2. Mag. 8 diam. Dorsal view of specimen showing keels on carapace and tail, the eyes, antennules and antennæ, the endopodites and exopodites of legs. This specimen was figured by R. Etheridge, jun., *Quart. Journ. Geol. Soc.*, vol. xxxv., pl. xxiii., fig. 4. The broken carapace of smaller specimen seen near the front of the right side was doubtfully considered to represent part of a chelate limb of the larger individual. Locality, Tweeden Burn, near junction with Liddel Water, New Castleton, Roxburghshire. M. 4249[B].

3. Mag. nearly 3 diam., showing breeding lamellæ. Locality, Gullane Shore, Haddingtonshire. M. 4844[E].

3A. Same, mag. over 9 diam. Shows appendages of first four segments, the wide sternum made up of the seven last trunk segments, both branches of several limbs on both sides with their gills, and the breeding lamellæ.

4. Mag. over 4 diam. Shows both trunk and tail appendages well, especially the endopodites of seven last trunk limbs of left side, all made on same type, as well as the exopodites of some of them and breeding lamellæ, and also the sternal branches of the gills, the pleopods, and the accessory swimmerets on telson. This specimen was also figured by R. Etheridge, jun. (*loc. cit.*, fig. 9). Same locality as fig. 2. M. 4246[B].

4A. Mag. 20 diam. Sternal branch of gill of fifth right leg. Same specimen as fig. 4.

5. Mag. over 4 diam. More slender form, supposed to be a male, also figured by R. Etheridge, jun. (*loc. cit.*, fig. 6). Shows head organs well, the ocular papilla, both branches of trunk limbs, the pleopods, the telson with the accessory swimmerets, and the uropods. Same locality as fig. 2. M. 4249[B].

6. Mag. 15 diam. Young form; shows arrangement of keels excellently. Also figured by R. Etheridge, jun. (*loc. cit.*, fig. 7). Same locality and same slab as figs. 2 and 5. M. 4249[B].

Figs. 7–9. *Tealliocaris woodwardi* (Etheridge), var. .. .. Page 22.

7. Nat. size. Showing elongated form of carapace. Locality, Chattlehope, Rede Water, Northumberland. R. 1709.

8. Slightly mag. Same locality. R. 1717.

9. Tail fan of another specimen from the same locality, a little more highly magnified. R. 1674.

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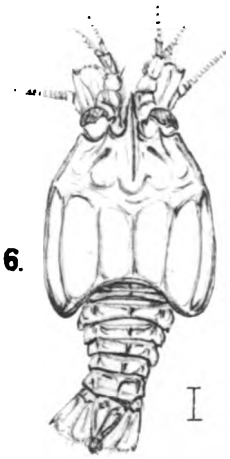

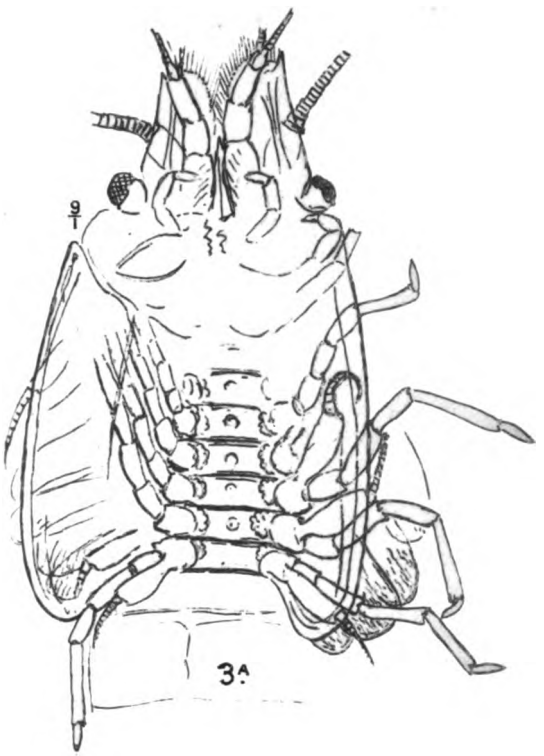

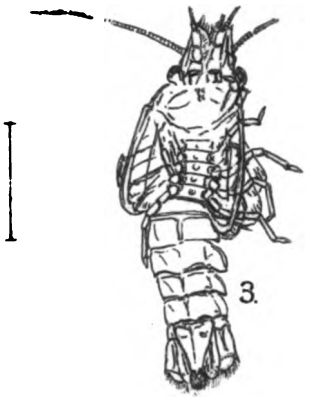

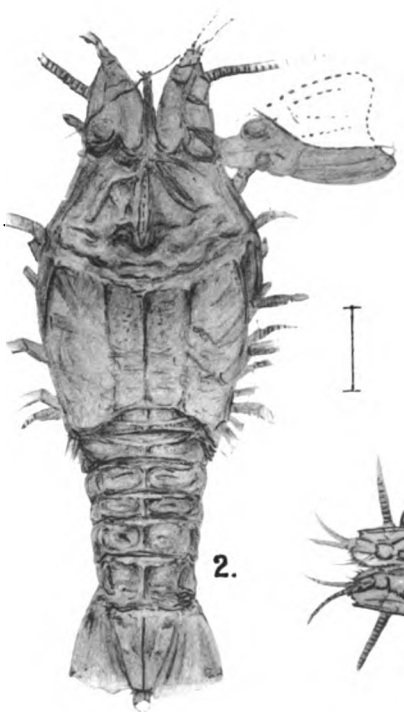

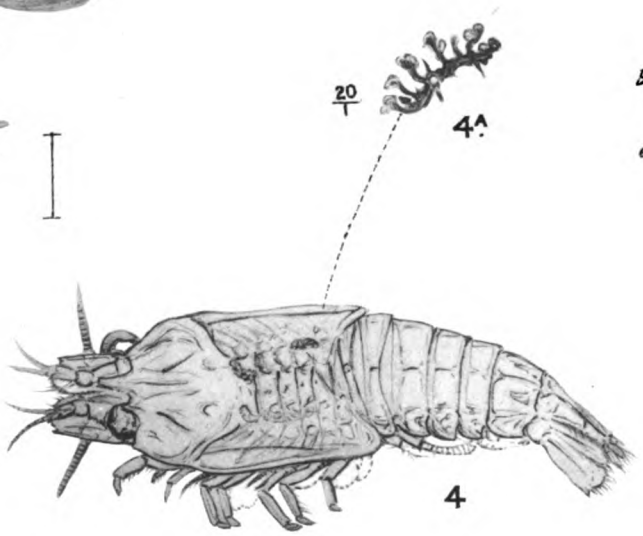

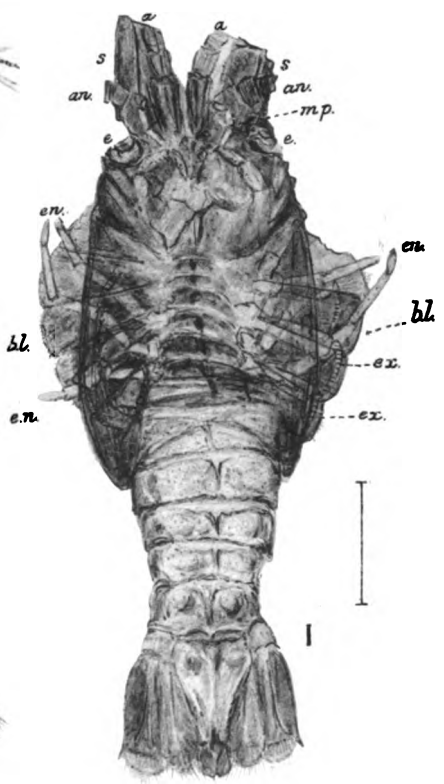

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PLATE III.

Figs. 1, 2. *Tealliocaris etheridgei* (Peach) .. .. Page 22
1. Mag. 2 diam. Reproduced from *Trans. Roy. Soc. Edin.*, vol. xxx., pl. viii., fig. 3b. Locality, Glencartholm, Langholm, Dumfriesshire. M. 780[C].
2. Mag. 2 diam. Reproduced from *loc. cit.*, fig. 3. Same locality. M. 1384[C].

Figs. 3, 4. *Tealliocaris etheridgei*, var. *lata* Peach .. .. Page 23.
3. Nat. size. Reproduced from *loc. cit.*, pl. xxviii., fig. 4. Same locality. M. 3086[C].
4. Nat. size. Reproduced from *loc. cit.*, pl. xxviii., fig. 4b. M. 2643[C].

Figs. 5–8. *Tealliocaris robusta* sp. nov. .. .. Page 24.
5. Mag. nearly 3 diam. Carapace (outside). Locality, Allanton Bridge, Whiteadder Water, Berwickshire. M. 2752[E].
6. Mag. 2 diam. Carapace (inside). Same locality. M. 2742[E].
7. Mag. 2 diam. Seen from beneath, showing sternites with attachment of limbs: *a.* antennular peduncle, *an.* antenna, *s.* basal scale, *en.* endopodite of trunk limb, *ex.* exopodite of same. Locality, Broomhouse, Duns, Berwickshire. M. 974[D].
8. Mag. 3 diam. Back view of tail. Locality, Allanton Bridge, Whiteadder Water, Berwickshire. M. 2739[E].

Figs. 9–12. *Tealliocaris robusta*, var. nov. .. .. Page 25.
9. Coutts Collection. Nat. size. Showing parts of trunk and tail. Locality, East Kilbride, Lanarkshire.
10. Coutts Collection. Nat. size. Underside of carapace. Same locality.
11. „ „ Nat. size. Outside of carapace. Same locality.
12. „ „ Mag. about 4 diam. Tail fan. Same locality.

Figs. 13–16. *Tealliocaris tarrasiana* sp. nov. .. .. Page 26.
13. Mag. 2 diam. Trunk with appendages: *a.* antennules, *an.* antenna, *s.* basal scale, *e.* eye, *en.* endopodites of seven trunk limbs of left side. Locality, Tarras Water, near Langholm, Dumfriesshire. M. 3158[C].
14. Mag. 2 diam. Trunk and tail; lettering as above. Same locality. M. 3181[C].
15. Trunk and tail. Same locality. M. 3422[C].
16. Mag. 3 diam. Restoration.

Figs. 17, 18. *Tealliocaris formosa* (Peach) .. .. Page 27.
17. Nat. size. Parts of trunk and tail. Reproduced from *Trans. Roy. Soc. Edin.*, 1883, vol. xxx., pl. xxviii., fig. 3. Locality, Glencartholm, Langholm, Dumfriesshire. M. 2508[C].
18. Nat. size. Part of tail. *Loc. cit.*, fig. 3b. Same locality. M. 2259[C].

Figs. 19–22. *Pseudo-Galathea macconochiei* (R. Etheridge, jun.).. .. .. .. Page 28.
19. Nat. size. Trunk and tail. Reproduced from *Trans. Roy. Soc. Edin.*, 1882, vol. xxx., pl. viii., fig. 6. Locality, Glencartholm, Langholm, Dumfriesshire. M. 2492[C].
20. Nat. size. Carapace. *Loc. cit.*, fig. 6b. Locality, Tweeden Burn, New Castleton, Roxburghshire. M. 4300[B].
21. Tail of fig. 19, magnified. *Loc. cit.*, fig. 6d.
22. Head organs of fig. 19, magnified from counterpart. *Loc. cit.*, fig. 6c.

Figs. 23, 24. *Pseudo-Galathea rotunda* Peach .. .. Page 28.
23. Nat. size. Seen from above. Shows sensory organs of head, wide sternites of trunk, with seven limbs attached on right side. Locality, Coomsdon Burn, Rede Water, Northumberland. R. 1513.
24. Mag. 4 diam. Shows trunk and tail, carapace with longitudinal keels, tail and tail fan. Same locality.

Figs. 25–29. *Pseudo-Galathea ornatissima* Peach .. .. Page 29.
25. Nat. size. Shows part of trunk and tail, eyes, antennæ, base of limbs on left side. Locality, Coomsdon Burn, Rede Water, Northumberland. R. 1702.
26. Nat. size. Trunk and tail, seen from beneath. Shows antennules, antennæ, eyes, wide sternites of trunk, tail segments, and details of tail fan. Same locality. R. 1670.
27. Nat. size. Tail segments and tail fan. Same locality. R. 1671.
28. Mag. 2 diam. Details of tail fan. Same locality. R. 1518.
29. Restoration.

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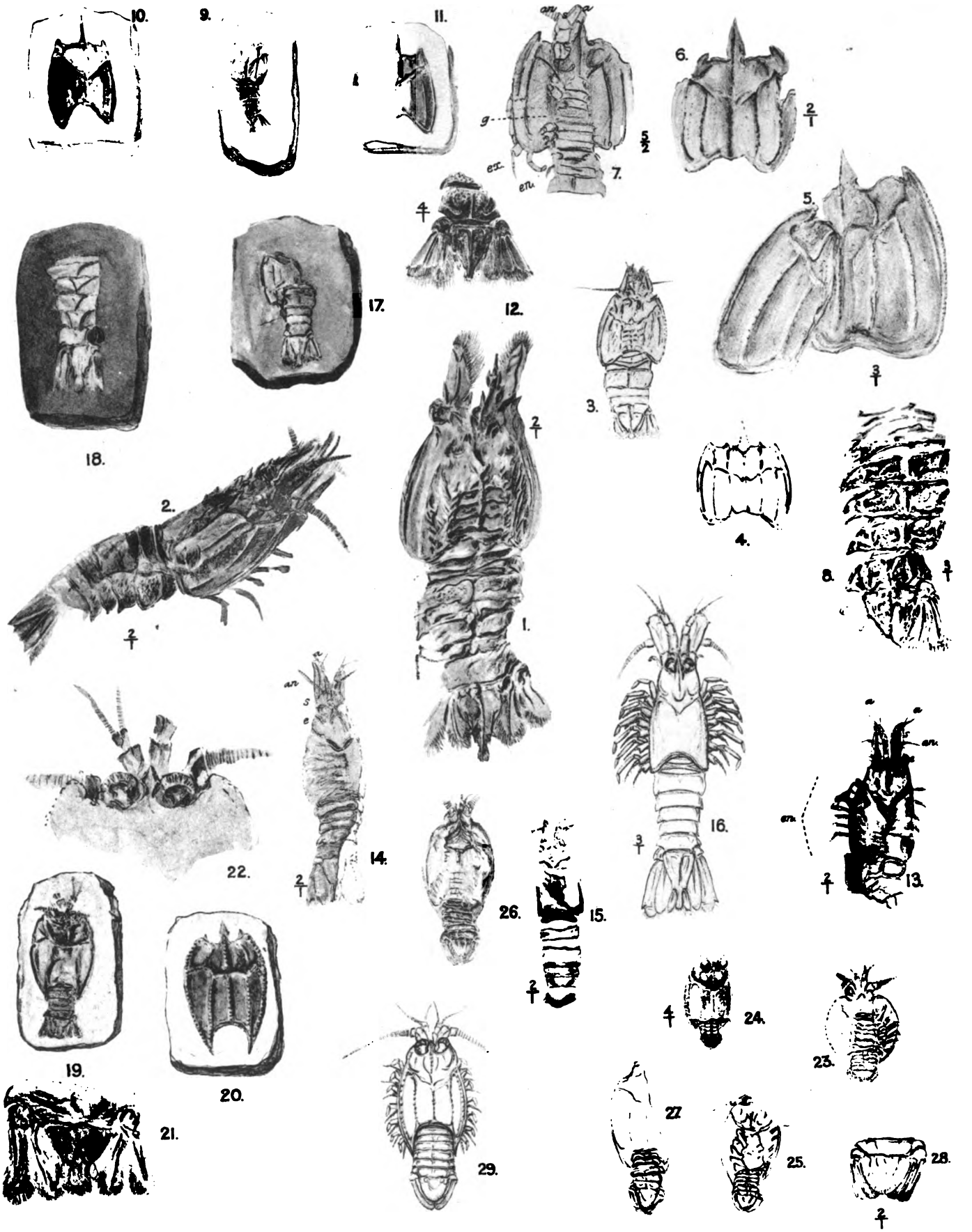

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PLATE IV.

Figs. 1–6. *Anthrapalæmon russellianus* (Salter) .. .. Page 30.

1. Mag. 3 diam. Carapace seen from above. Locality, Greengairs, 3½ miles N.N.E. of Airdrie, Lanarkshire. T. 2763[B].

2. Mag. 3 diam. Underside of trunk showing wide sternites, with row of plates (*pla.*) and gills (*g*) on left side (right hand of observer), beyond which are seen fragments of both branches of seven limbs: *an.* antenna, *e.* eye, *m.p.* mandibular palp, *m.* body of mandible, m^1. molar edge of mandible, *ma.* maxillæ, *max.p.* palp of maxillipede, *m.g.* ? papillæ upon which the male genital organs open, *d.* doublure of carapace. Same locality. T. 2766[B].

3 Presented to Survey Collection by R. Dunlop. Mag. 2 diam. Trunk and part of tail seen from above. The specimen is partly preserved in iron pyrites, and the carapace has broken away with the counterpart revealing the ventrally-placed organs, which are somewhat displaced: *e.* eyes, *a.* antennules, *an.* antennæ, *s.* basal scale, *m.* mandible, *m.p.* mandibular palp, *c.* carapace, *en.* endopodites of trunk limbs, *ex.* exopodites of same, *g.* gills. The backs of the anteriorly placed tail segments are seen, and where they are broken away the wide sternites of one segment with the articulations for the pleopods can be seen. The tail is folded up, and this reveals the natural arching of the body where the segments lie at right angles to the bedding planes of the shaly ironstone. Same locality.

4. A little over nat. size. Carapace folded together. Shows the serrated side-keels, the doublure (*d.*), and the short conical forwardly-directed spines on sides of carapace. Same locality. T. 2753[B].

5. Presented to Survey Collection by R. Dunlop. Mag. 3 diam. Part of tail and tail fan: *t.l.* terminal lobe, *a.s.* accessory swimmerets. Same locality.

6. Dunlop Coll. Nat. size. Sketch of specimen belonging to Mr. R. Dunlop, showing the trunk and tail. The position of the sense organs of head is well seen. The tail is slightly displaced or driven in, but the tail fan is well shown. Same locality.

Fig. 7. *Anthrapalæmon russellianus*, var. *spinulosus* var. nov. Mag. 1½ diam. Carapace seen from above. Same locality. T. 2768[B]. .. .. Page 36.

Figs. 8–10. *Pygocephalus cooperi* Huxley .. .. Pages 33, 37.

8. Mag. 1½ diam. Reproduction of Huxley's original figure from *Quart. Journ. Geol. Soc.*, 1857, vol. xiii., pl. xiii., fig. 1b, p. 367, for comparison with figs. 2 and 3 (above), and with plates i., ii., and iii.

9. Mag. 1½ diam. Reproduction of Huxley's figure, *loc. cit.*, fig. 3, for comparison.*

10. Nat. size. Reproduction of figure by H. Woodward of Scottish specimen from Kilmaurs, Ayrshire, taken from *Trans. Geol. Soc. Glasgow*, 1867, p. 234, pl. iii., fig. 2, for comparison.

* Figs. 8 and 9 are drawn of the same size as Huxley's original figures, and are therefore magnified 1½ diameters, not 2 diameters as shown in present plate.

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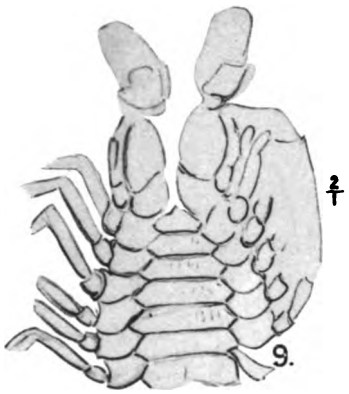

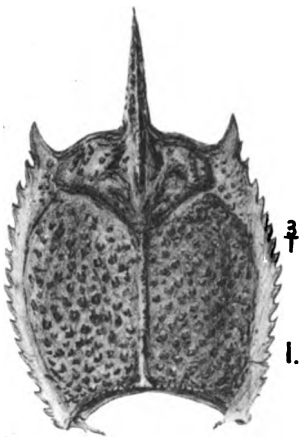

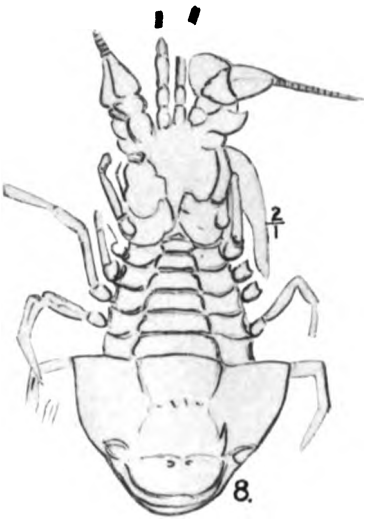

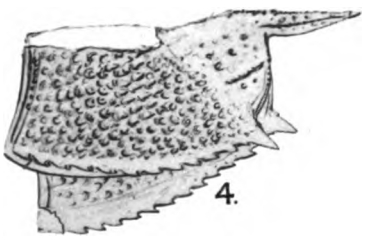

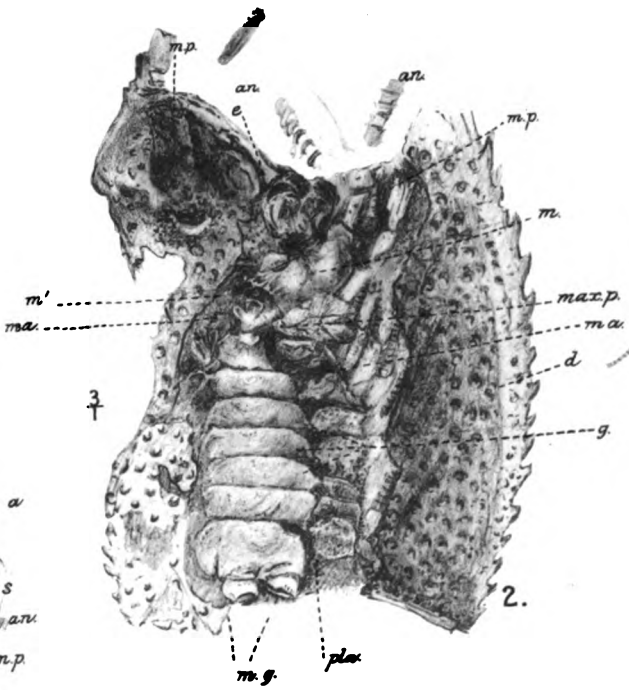

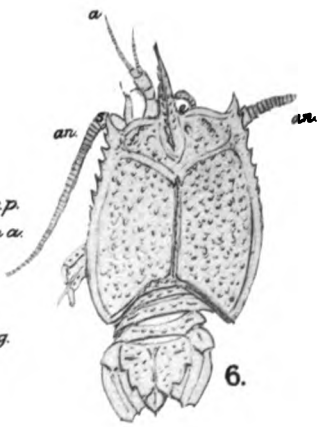

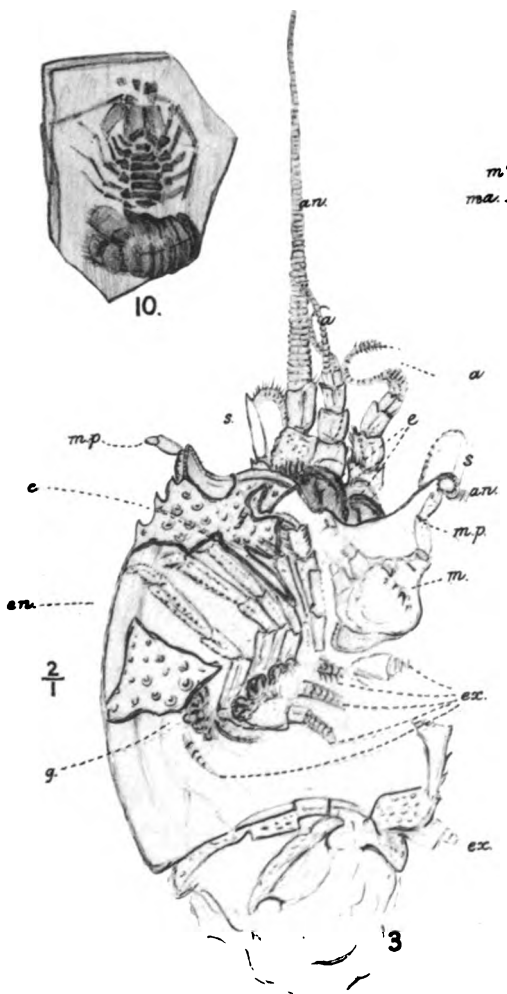

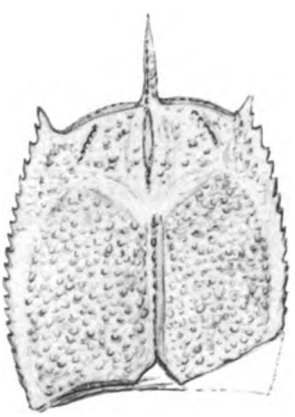

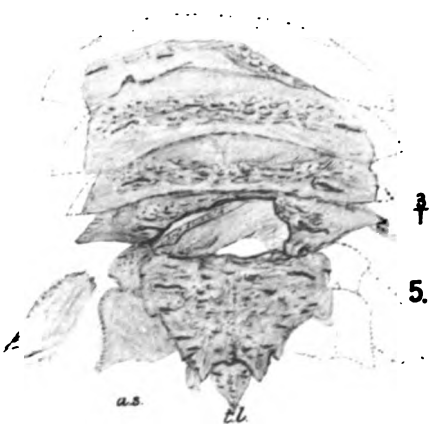

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PLATE V.

Figs. 1–5. *Perimecturus parki* (Peach) .. .. Page 40.

1. Nat. size. Shows part of trunk and tail of one of the largest specimens. Locality, Glencartholm, Langholm, Dumfriesshire. M. 789^{c}.

2. Nat. size. Almost complete tail fan of very large individual. Same locality. M. 3091^{c}.

3. Nat. size. Part of trunk and tail of moderately large individual, showing movable rostrum, eye, the antennules, antennæ with basal scale. Same locality. M. 2180^{c}.

4. Nat. size. Head and trunk of small specimen partly preserved in relief. Shows details of keels on carapace and tail and nature of tail fan. Same locality. M. 1564^{c}.

5. Nat. size. Part of trunk and tail. Shows some of the trunk limbs. Same locality. M. 2825^{c}.

Fig. 6. *Perimecturus parki*, var. *duplicicarinatus* var. nov. Nat. size. Trunk and tail preserved in relief, showing double row of keels down the middle of the tail. Same locality. S. 3. .. .. Page 41.

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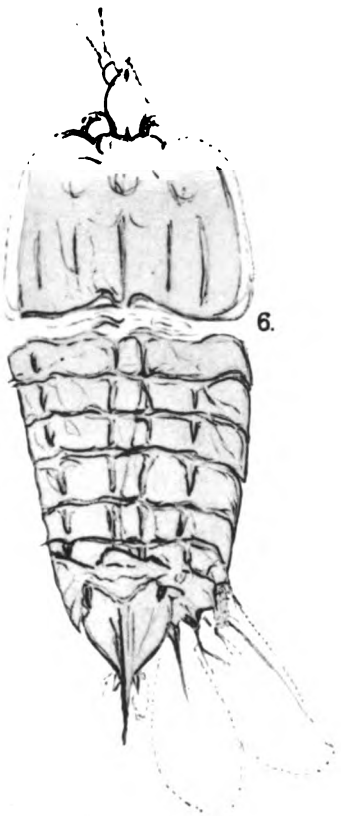
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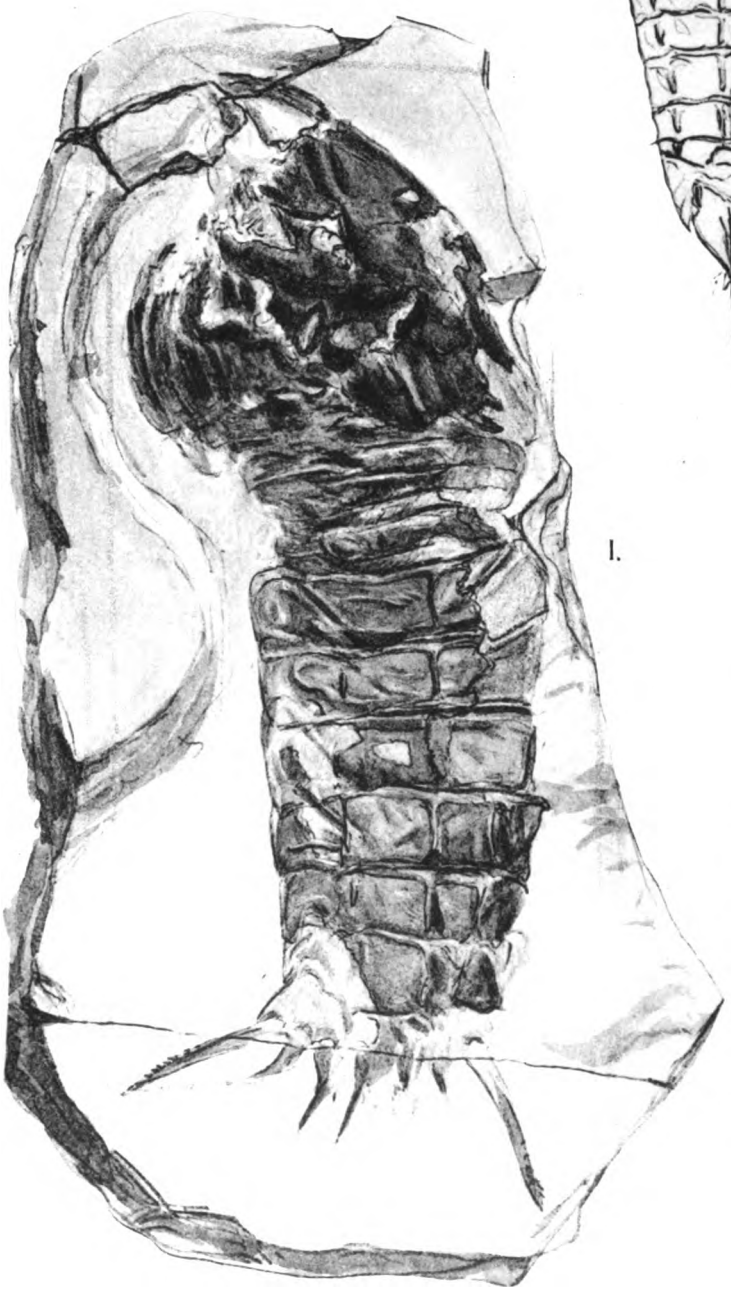
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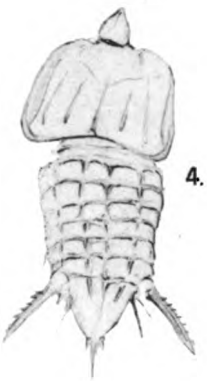
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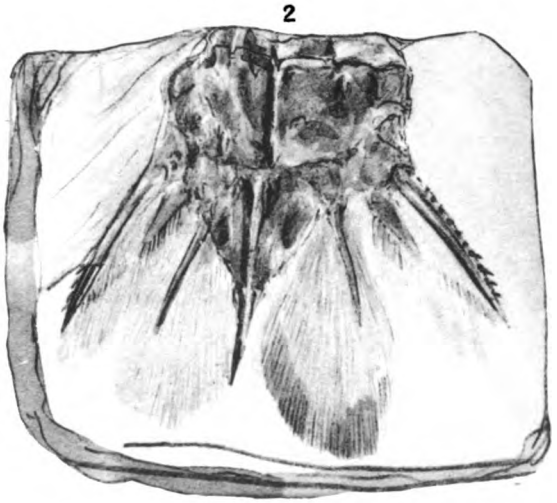
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PLATE VI.

Fig. 1. *Perimecturus stocki* sp. nov. .. .. Page 42.

1. Geol. Surv. Coll., acquired. Nat. size. Part of trunk and tail, showing trunk segments with broad sternites, trunk limbs, three-quarter view of under side of tail showing sternites with large openings for articulation of pleopods, tail fan with very massive outer branch of uropods. Locality, Granton Shore, Midlothian. S. 23.

Figs. 2–6. *Perimecturus elegans* sp. nov. .. .. Page 44.

2. Nat. size. Trunk and tail in usual attitude, showing displaced carapace exposing trunk segments, displaced head and trunk organs, tail with three rows of spines in place of keels. Locality, Glencartholm, Langholm, Dumfriesshire. M. 697^{c}.

2A. Part of fig. 2, mag., showing displaced head and trunk organs: *a.* antennules, *an.* antennæ, *e.* eye, *r.* rostrum, *m.p.* ? mandibular palp, *end.* endopodites of trunk limbs, *ex.* exopodites of same, *g.* gills, *b.p.* brood-pouch.

3. Nat. size. Trunk and tail of small individual in usual attitude. Shows movable rostrum, trunk limbs, epimera of tail segments. Same locality. M. 2804^{c}.

4. Mag. 2 diam. Trunk and part of tail, usual attitude. Shows displaced carapace exposing the trunk segments, displaced limbs. Same locality. M. 702^{c}.

5. Nat. size. Trunk and part of tail, usual attitude; movable rostrum, trunk limbs, and distribution of spines on tail. Same locality. M. 775^{c}.

6. Nat. size. Tail with two trunk segments attached, and tail fan expanded. Same locality. M. 2615^{c}.

Fig. 8. Recent *Mysis*, mag. 3 diam., to show attitude assumed on dying, to compare with plates v., vi., vii., especially pl. vi., figs. 1–5. Locality, Firth of Forth, Granton, Midlothian. Page 39.

Fig. 9. *Perimecturus pattoni* sp. nov. Coutts Collection. Nat. size. Parts of trunk and tail. Shows brood-pouches. Locality, East Kilbride, Lanarkshire. .. .. Page 51.

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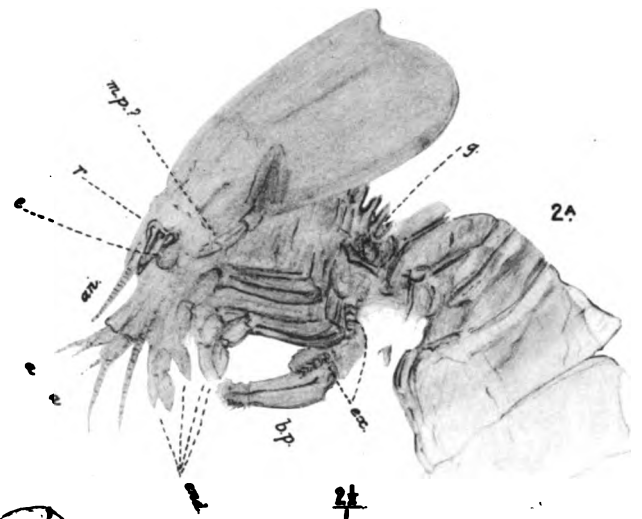

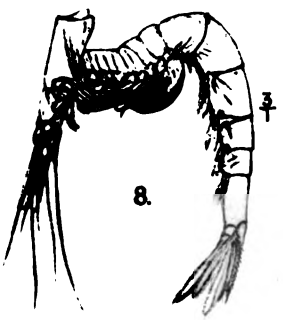

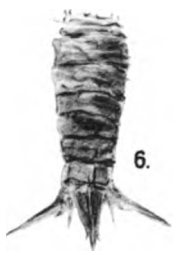

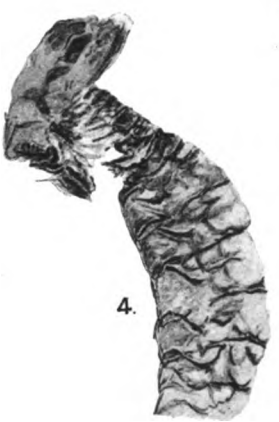

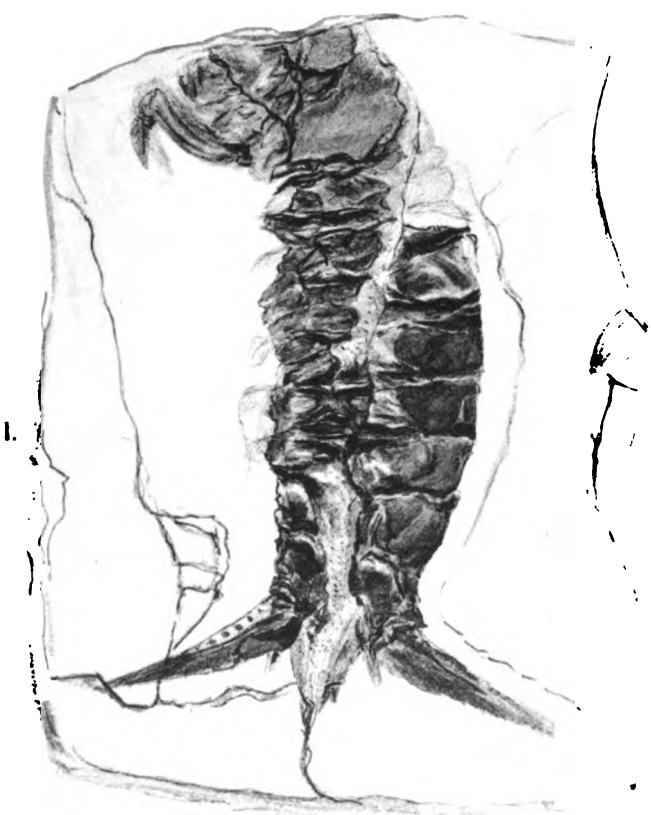

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PLATE VII.

Figs. 1–5. *Perimecturus communis* sp. nov. .. .. Page 47.

1. Nat. size. Trunk and tail in usual attitude, exposing trunk segments. Shows movable rostrum, eye, trunk segments, trunk limbs folded up and slightly clenched (compare with recent *Anaspides*, pl. viii., fig. 11), tail segments and pleopods. Locality, Glencartholm, Langholm, Dumfriesshire. M. 1417[C].

2. Nat. size. Part of tail and trunk in usual attitude. Same locality. M. 692[C].

3. Nat. size. Under view of tail showing the epimera, the sternites pierced for articulation of pleopods, expanded tail fan, telson with accessory swimmerets. Same locality. M. 3211[C].

4. Nearly complete small individual, showing both trunk and tail in side view, with carapace in place exposing the terga of last two trunk segments in mid-line of back. Shows rostrum, eye, antennules, antenna with scale, trunk limbs tightly clenched and doubled up in usual attitude, massive tail with characteristic overlapping epimera, and tail fan. Same locality. M. 2739[C].

5. Nat. size. Trunk and tail in usual attitude, displaced carapace with movable rostrum, exposed trunk segments, trunk limbs clenched and folded up forward, tail segments with characteristic epimera, and telson with accessory swimmerets. Same locality. M. 696[C].

Fig. 6. Recent squillid, *Gonodactylus chiragra* Latreille, for comparison (nat. size) .. Page 48.

Fig. 6A. Broken-off raptorial limb of fig. 6.

Fig. 7. Tail of fig. 6 drawn in same attitude as fig. 3 for comparison.

Figs. 8–14. *Perimecturus ensifer* sp. nov. .. .. Page 49.

8. Nat. size. Trunk and tail of small specimen seen from beneath. Shows carapace with leaf-like rostrum, sternites of trunk and tail, epimera of tail segments, and expanded tail fan. Locality, Glencartholm, Langholm, Dumfriesshire. M. 415[C].

9. Nat. size. Tail and tail fan. Figured by R. Etheridge, jun., as *Dithyrocaris* sp. ind., *Quart. Journ. Geol. Soc.*, 1879, vol. xxxv., pl. xxiii., fig. 2. Locality, Liddel Water, half-a-mile below New Castleton, Roxburghshire. M. 4260[B].

10. Nat. size. Tail and tail fan in side view, detached sense organs of head, eyes, antennular peduncle, antenna, and scale. Same locality. M. 4882[B].

11. Nat. size. Part of tail and fan of larger individual. Same locality. M. 4267[B].

12. Nat. size. Part of tail with telson showing characteristic ornament. Figured by R. Etheridge, jun., *loc. cit.*, fig. 3. Same locality. M. 4265[B].

13. Telson of another individual, seen from beneath. Shows accessory swimmerets, two on one side. Same locality. M. 4883[B].

14. Part of fig. 13 enlarged.

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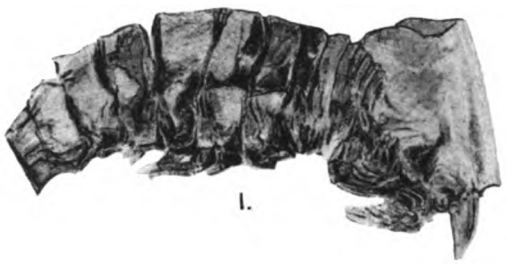
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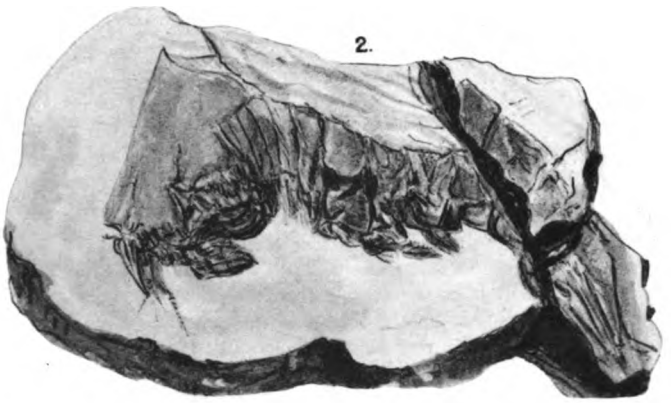
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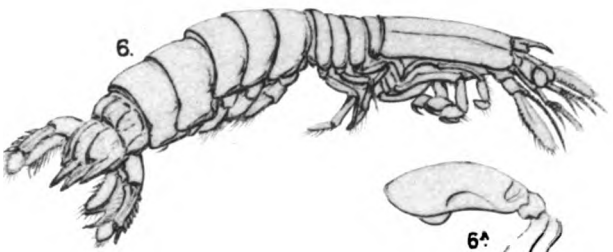
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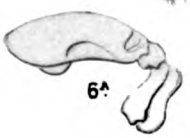
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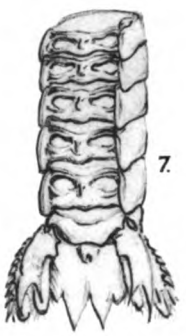
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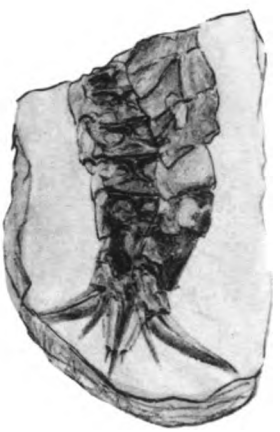
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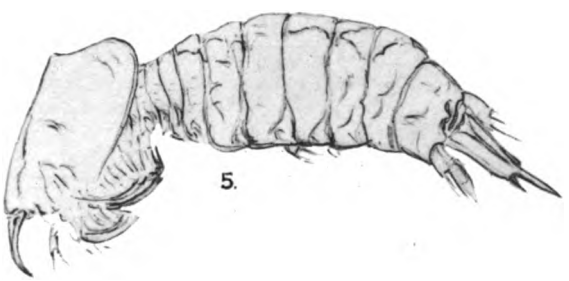
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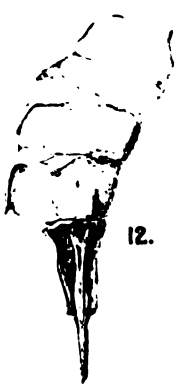
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PLATE VIII.

Figs. 1–5. *Palæocaris scotica* Peach . . . . . Page 54.

1. Mag. 2½ diam. Reproduction of original figure from *Trans. Roy. Soc. Edin.*, 1882, vol. xxx., pl. x., fig. 10. Locality, Glencartholm, Langholm, Dumfriesshire. M. 3349^{C}.
2. Mag. 3 diam. Reproduction of figure, *loc. cit.*, fig. 10. Same locality. M. 1542^{C}.
3. Mag. 5 diam. Reproduction of figure, *loc. cit.*, fig. 10a. Same locality. M. 1347^{C}.
4. Mag. 10 diam. To show difference between trunk and tail segments; also shows fragments of trunk limbs. Same locality. M. 1346^{C}.
5. Restoration of tail fan. Reproduction of figure, *loc. cit.*, fig. 10h.

Figs. 6 and 7. *Palæocaris typus* Meek and Worthen.

6. Reproduction of figure by Meek and Worthen, from *Mem. Geol. Survey of Illinois, U.S.A.*, vol. ii., pl. xxxii., for comparison.
7. Reproduction of restoration of tail fan by Meek and Worthen, *loc. cit.*

Figs. 8–10. *Palæocaris landsboroughi* sp. nov. . . . . Page 55.

8. Nat. size. Trunk and tail showing head appendages and tail fan. Locality, Kilmaurs, Ayrshire. (Specimen presented.)
9. Counterpart of fig. 8.
10. Restoration of parts seen, magnified.

Fig. 11. *Anaspides tasmaniæ* G. M. Thomson . . . . . Page 53.

11. Reproduction of Calman's figure of the recent *Anaspides* from *Trans. Roy. Soc. Edin.*, 1897, vol. xxxviii., pl. i., fig. 1, for comparison.

Figs. 12–14. *Palæmysis dunlopi* sp. nov. . . . . Page 57.

12. Mag. 3 diam. Tail and tail fan. Locality, Greengairs, 3½ miles N.N.E. from Airdrie, Lanarkshire. T. 2769^{B}.
13. Mag. 3 diam. Tail and tail fan showing auditory organs on uropods. Same locality. T. 2767^{B}.
14. Mag. 4 diam. Tail fan showing auditory organs on uropods. Same locality. Presented by R. Dunlop.

Fig. 15. Magnified tail fan of recent *Mysis* for comparison.

Figs. 16–19. *Palæmysis couttsi* sp. nov. . . . . Page 59.

16. Coutts Coll. Nat. size. Tail fan. Locality, Cementstone Quarry, East Kilbride, Lanarkshire.
17. „ „ Nat. size. Tail fan. Same locality.
18. „ „ Nat. size. Tail fan. Same locality.
19. Restoration of tail fan.

Figs. 20–24. *Palæmysis tenuis* sp. nov. . . . . Page 60.

20. Nat. size. Tail fan. Locality, Glencartholm, Langholm, Dumfriesshire. M. 648^{C}.
21. Nat. size. Tail fan. Same locality. M. 2780^{C}.
22. Nat. size. Tail and tail fan. Same locality. M. 3234^{C}.
23. Nat. size. Carapace and tail. Same locality. M. 1412^{C}.
24. Restored tail fan, slightly magnified.

Fig. 25. *Palæmysis* sp. ind. . . . . Page 60.

25. Part of tail and fan. Locality, Glencartholm, Langholm. M. 2390^{C}.

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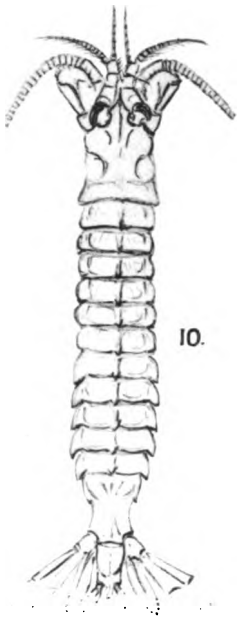
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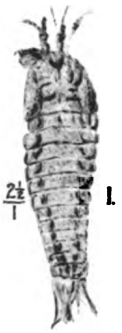
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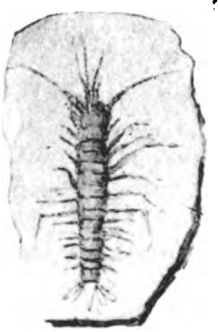
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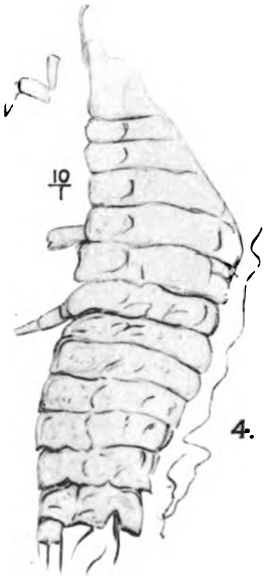
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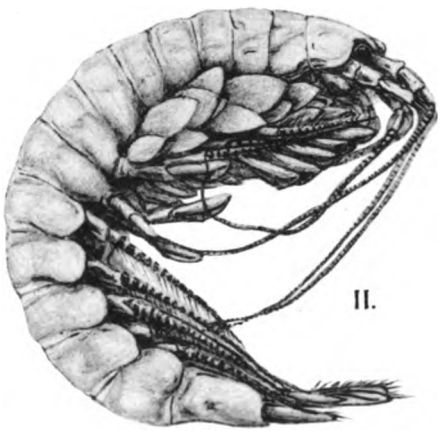
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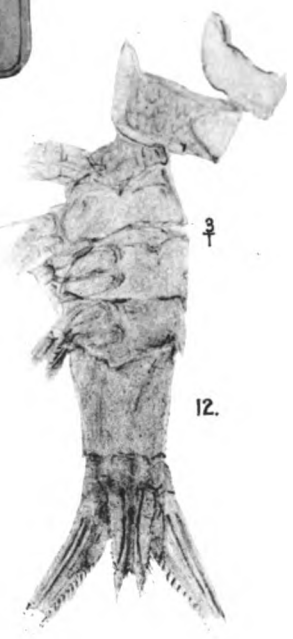
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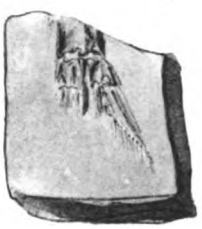
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PLATE IX.

Figs. 1–10. *Anthracophausia dunsiana* sp. nov. .. .. Page 61.

1. Mag. 3 diam. Trunk and tail of adult male: *e.* eye, *a.* antennule, *an.* antennæ, *s.* basal scale, *max.* maxillipede, *end.* endopodites of seven pairs of trunk limbs, *l. e.s.** luminous bodies, 1, 2. pleopods of first and second pairs, *gu.* gut. Locality, Whiteadder Water, near Duns, Berwickshire. M. 860[D].

1A. Luminous body on trunk of fig. 1, enlarged.

1B. Tip of male pleopod of first pair, with coupling hooks, further magnified from fig. 1.

2. Mag. 3 diam. Trunk and tail of female; lettering as in fig 1. Same locality. M. 847[D].

3. Mag. 3 diam. Trunk and part of tail of adult male. Shows head organs: *m.p.* mandibular palp., *m.* body of mandible; other lettering as in fig. 1. Same locality. M. 3494[C].

4. Mag. 3 diam. Adult male; lettering as above. Same locality. M. 801[D].

5. Mag. 3 diam. Tail: *a.s.* accessory swimmerets on telson; lettering as above. Same locality. M. 865[D].

6. Mag. 3 diam. Trunk and tail, back view. Shows course of gut. Same locality. M. 685[D].

7. Magnified head organs seen from beneath. Shows basal joints of antenna. M. 741[D].

8. Mag. 3 diam. Tail seen from beneath. Shows portion of anus. M. 868[D].

9. Restoration of tail fan, magnified.

10. Mag. 2 diam. Carapace and head organs. Locality, Glencartholm, Langholm. M. 2262[C].

Figs. 11–15. *Anthracophausia dunsiana*, var. *obesa* var. nov. .. .. Page 66.

11. Mag. 3 diam. Adult male, showing pleopods of first and second pair; lettering as above. Locality, Whiteadder Water, Duns, Berwickshire. M. 3514[C].

12. Mag. 2 diam. Trunk and tail of female, showing head organs. Locality, Glencartholm, Langholm, Dumfriesshire. M. 2280[C].

13. Mag. 2 diam. Carapace of female. Same locality. 2714[C].

14. Mag. 3 diam. Carapace and head organs. Same locality. M. 2256[C].

15. Mag. 3 diam. Tail fan and last segment. Same locality. M. 2614[C].

16. Tail fan of recent *Euphausia pellucida* Dana, after G. O. Sars, for comparison.

* Owing to a mistake, the luminous organs on the tail of fig. 1 are lettered *e* instead of *l*.

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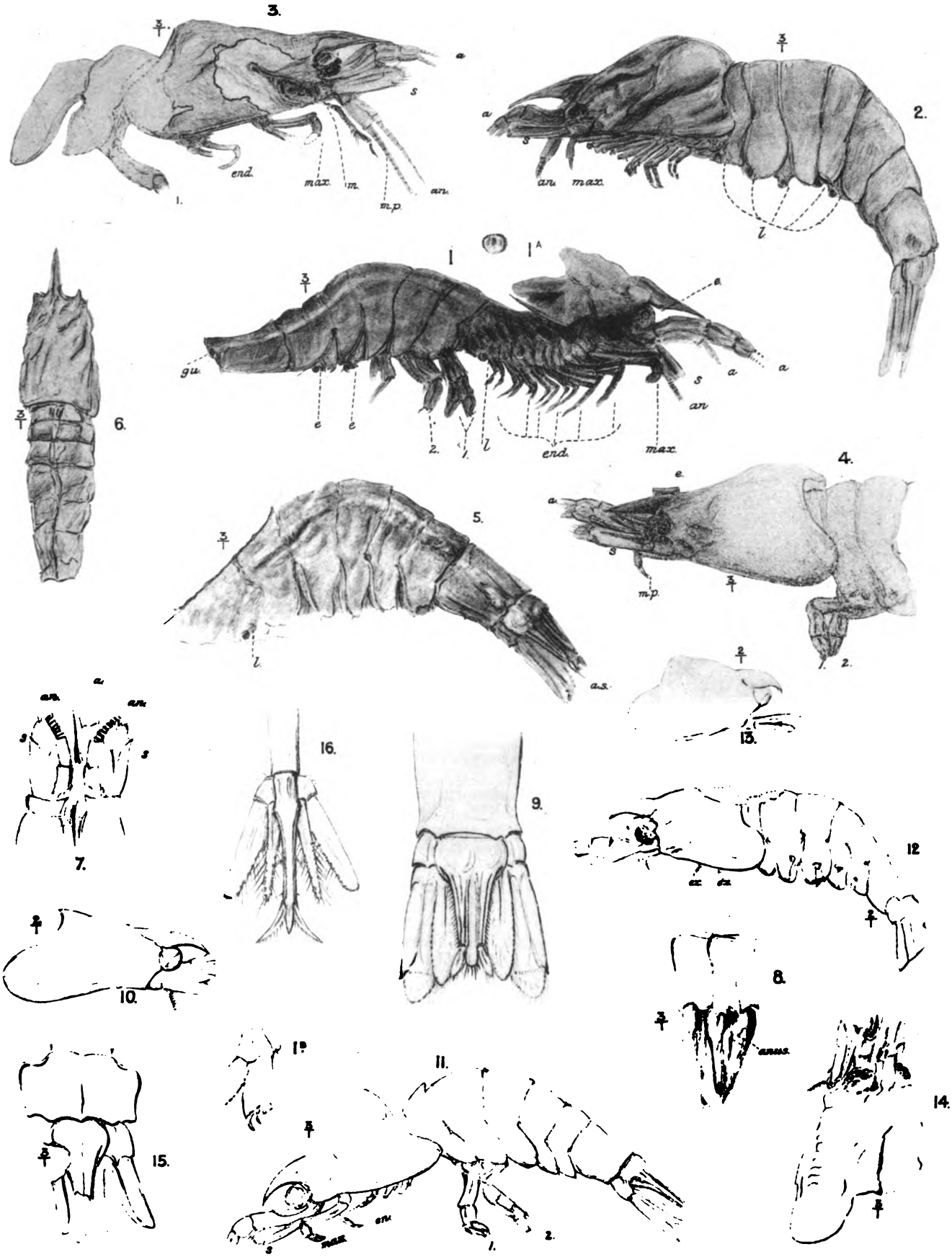

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PLATE X.

Figs. 1–5. *Anthracophausia traquairi* (Peach) .. .. Page 67.

1. Nat. size. Reproduction of original figure from *Trans. Roy. Soc. Edin.*, 1882, vol. xxx., pl. x., fig. 5a. Locality, Glencartholm, Langholm, Dumfriesshire. M. 694^{c}.

2. Nat. size. Reproduction of fig. 5b, *loc. cit.* Same locality. M. 941^{c}.

3. Nat. size. Trunk and tail of (?) female preserved in relief: *r.* rostrum, *s.* basal scale of antenna, *m.* mandible, *en.* endopodites of trunk limbs, *ex.* exopodites of same; 1–5. basal joints of pleopods. Same locality. M. 2582^{c}.

4. Nat. size. Counterpart of fig. 3.

5. Branch of gill of fig. 1, magnified.

Fig. 6. Branch of gill of recent *Euphausia pellucida* Dana, magnified, after G. O. Sars, for comparison. .. .. Page 69.

Figs. 7–11. *Crangopsis socialis* Salter .. .. Page 69.

7. Presented to the Survey Collection by Wm. Anderson. Mag. 3 diam. Trunk and part of tail of (?) female: *e.* eye, *a.* antennules, *an.* antennæ, *s.* basal scale, *en.* endopodites of trunk limbs; 1–5. pleopods of tail segments. Locality, Ardross Shore, near St. Monans, East Fife.

8. Presented by Wm. Anderson. Mag. 3 diam. Trunk and tail of another (?) female: g^{l}. ? gills; other lettering as above. Same locality.

9. Presented by Wm. Anderson. Mag. 3 diam. Tail of male showing underside: 1. pleopods of first pair, 2. pleopods of second pair, *anu.* anus. Same locality.

10. Presented by Wm. Anderson. Mag. 3 diam. Part of tail and fan. Same locality.

11. Restoration of male. Magnified about 2 diam.

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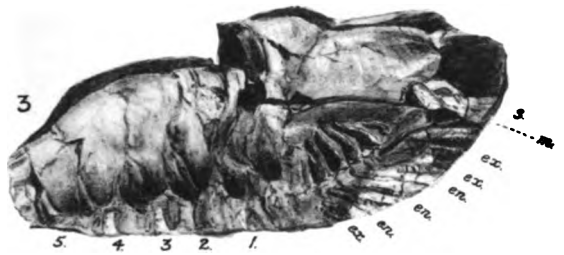
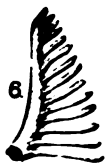
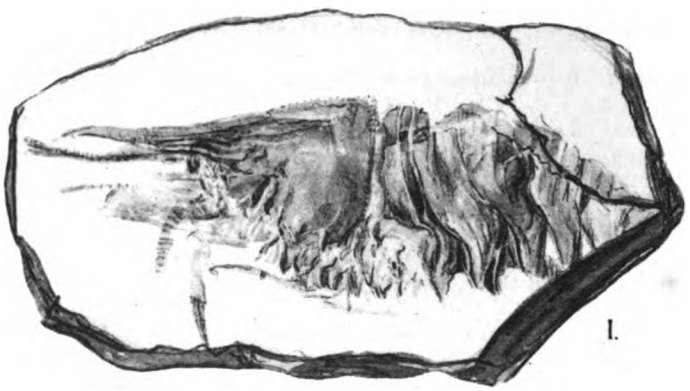
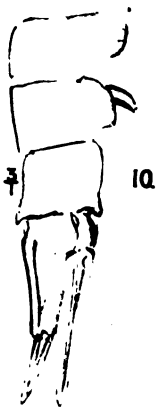
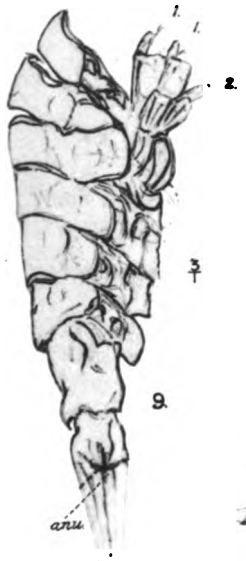
PLATE 10.

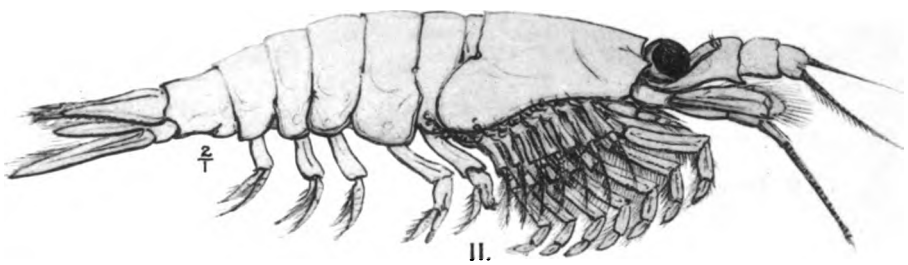


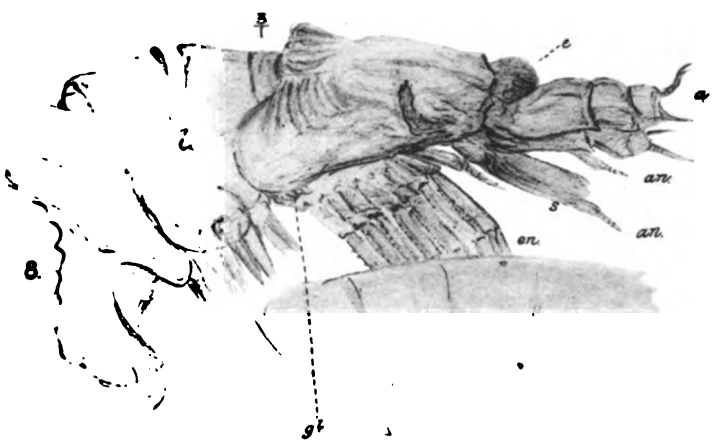












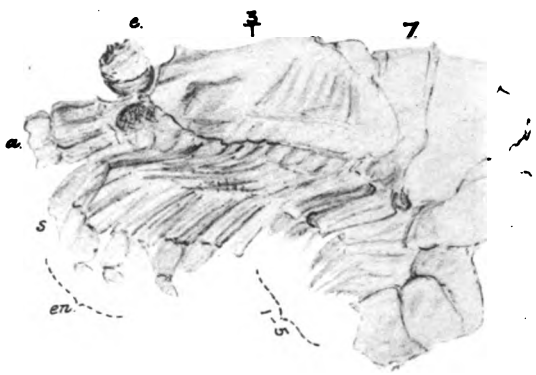


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PLATE XI.

Figs. 1–7. *Crangopsis eskdalensis* (Peach) .. .. Page 80.

1. Nat. size. Trunk and tail. Shows characteristic epimeron of second tail segment, Reproduction of original figure from *Trans. Roy. Soc. Edin.*, 1882, vol. xxx., pl. viii., fig. 9. Locality, Glencartholm, Langholm, Dumfriesshire. M. 284^{C}.
2. Nat. size. Trunk and tail of male. Reproduction of fig. 9c, *loc. cit.* Same locality. M. 285^{C}.
3. Nat. size. Male. Shows antennules, basal scale of antenna, mandibular palp, pleopods of first and second pair. Reproduction of fig. 9b, *loc. cit.* Same locality. M. 425^{C}.
4. Nat. size. Tail fan. Reproduction of fig. 9h, *loc. cit.* Same locality. M. 664^{C}.
5. Nat. size. Trunk and tail, showing eye, antennules, antenna and scale, and characteristic epimeron of second tail segment. Reproduction of fig. 9a, *loc. cit.* Same locality, M. 77^{C}.
6. Magnified. Pleopod of first pair of male (fig. 3). Reproduction of fig. 9f, *loc. cit.*
7. Restoration of tail fan. Reproduction of fig. 9k, *loc. cit.*

Fig. 8. *Crangopsis huxleyi* (H. Woodward) .. .. Pages 38, 82.

8. Reproduction of H. Woodward's figure of *Pygocephalus huxleyi*, from *Trans. Geol. Soc. Glasgow*, 1867, vol. ii., p. 245, fig. 2.

Figs. 9, 10. *Crangopsis elegans* (Peach) .. .. Page 81.

9. Nat. size. Trunk and tail. Reproduced from *Trans. Roy. Soc. Edin.*, 1883, vol. xxx., pl. xxviii., fig. 8. Locality, Glencartholm, Langholm. M. 3340^{C}.
10. Mag. 4 diam. Trunk and tail, showing antennule and tail fan. Locality, Whiteadder Water, Duns, Berwickshire. M. 963^{D}.

Figs. 11–14. *Crangopsis rhodesi* sp. nov. .. .. Page 73.

11. Mag. 3 diam. Two specimens. One, a female, shows eyes, antennules, antenna and scale, endopodites and exopodites of trunk limbs, brood sacs. The other, probably a male, shows head organs and tail fan. Locality, Chattlehope, Redesdale, Northumberland. Counterpart of R. 1681.
12. Telson, magnified. Same locality.
13. Magnified restoration of tail fan.
14. Magnified restoration.

Fig. 15. *Crangopsis magna* sp. nov. .. .. Page 75.

15. Nat. size. Part of trunk and tail of male. Shows modified pleopods of first and second pair. Glencartholm, Langholm, Dumfriesshire. M. 2245^{E}.

Figs. 16–18. *Crangopsis minuta* sp. nov. .. .. Page 80.

16. Mag. 3 diam. Shows head organs and tail fan. Locality, Coosmdon Burn, Rede Water, Northumberland.
17. Mag. 3 diam. Trunk and tail. Same locality.
18. Mag. 9 diam. Tail fan.

Figs. 19, 20. *Crangopsis hastata* sp. nov. .. .. Page 82.

19. Mag. 4 diam. Tail fan, seen from above. Locality, Chattlehope, Rede Water, Northumberland.
20. Mag. 4 diam. Tail fan, seen from side and beneath. Locality, Chattlehope, Rede Water, Northumberland.

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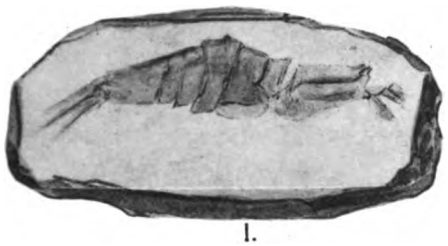
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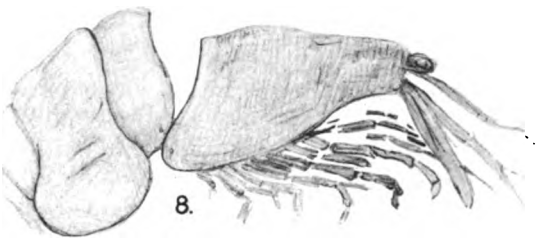
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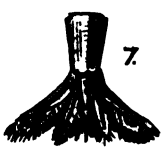
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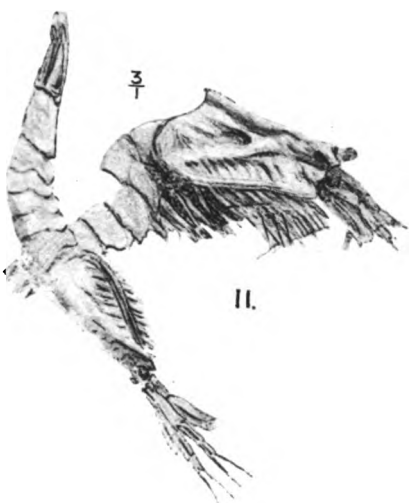
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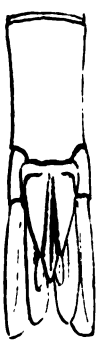
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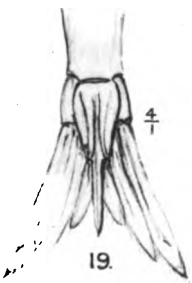
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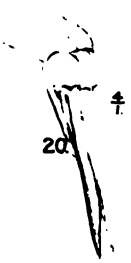
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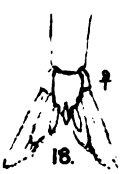
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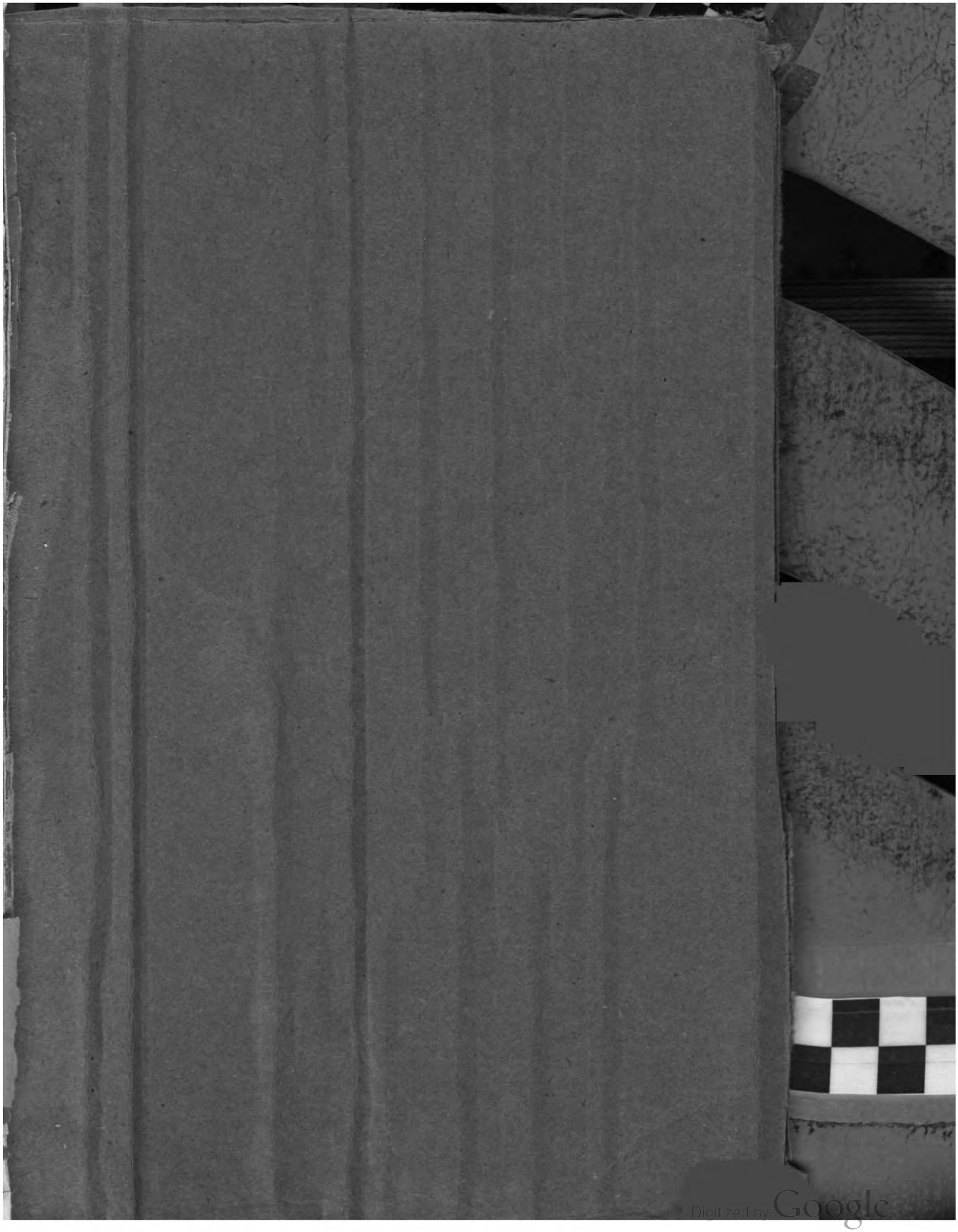
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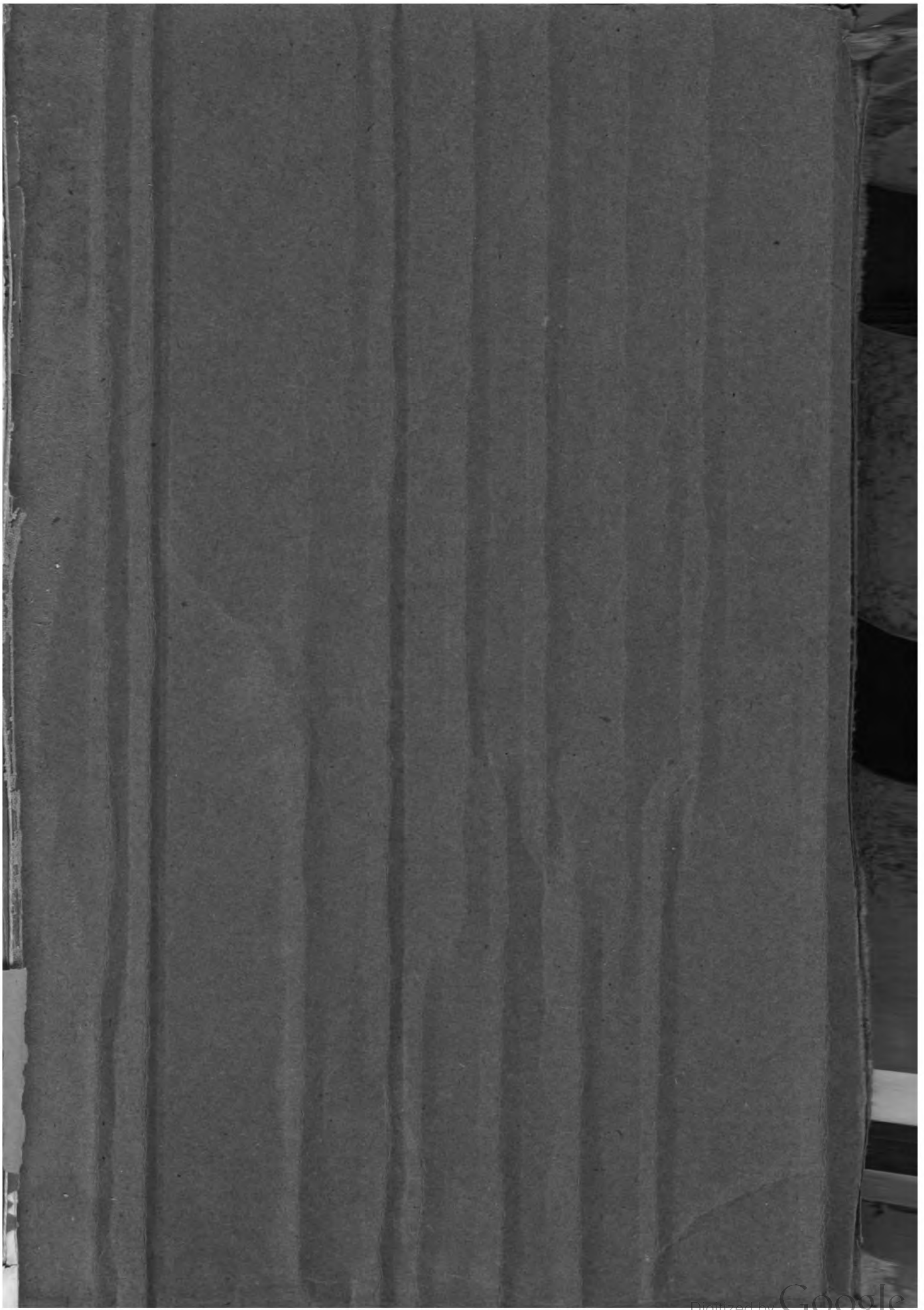
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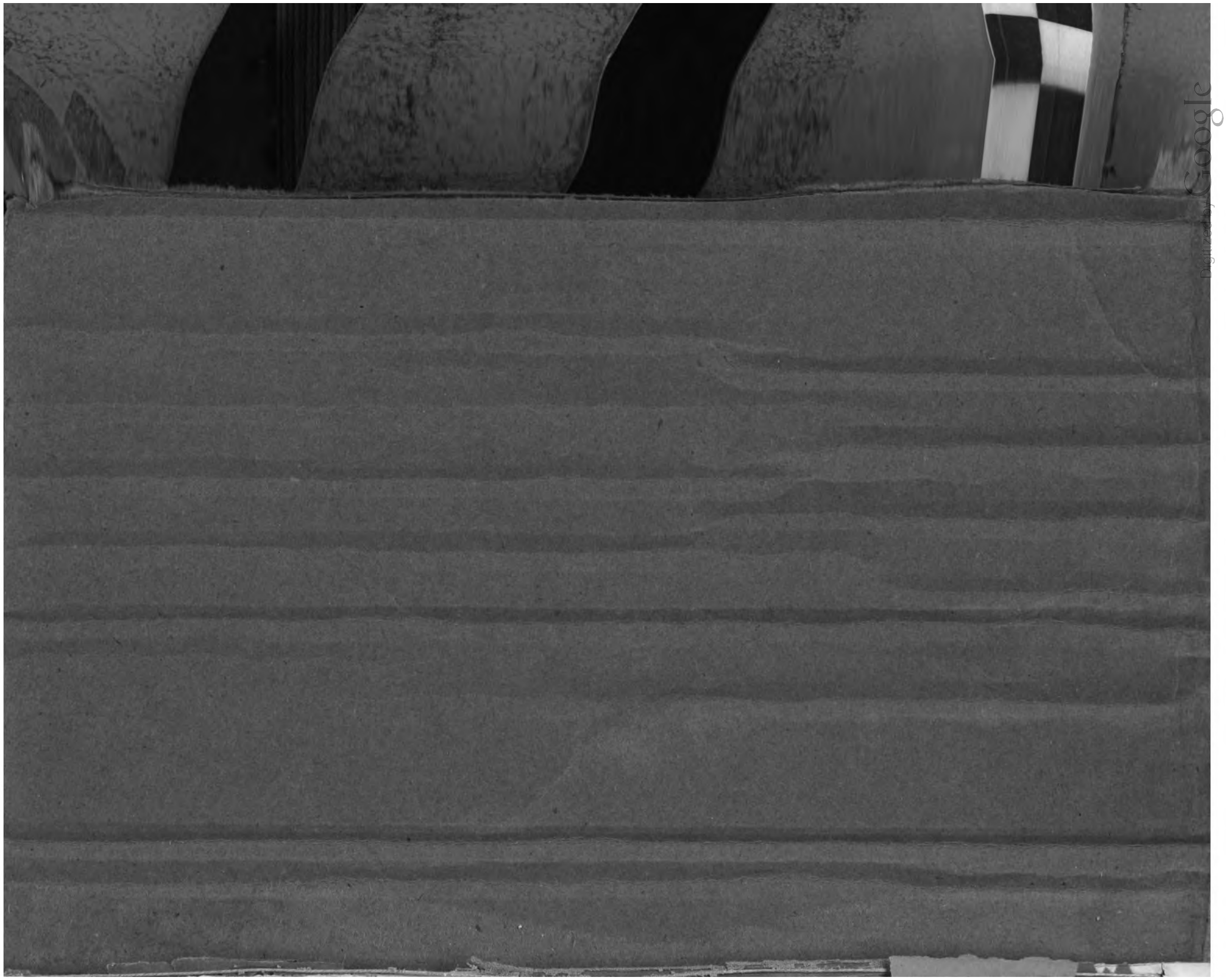
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